THE GLASS INDUSTRY
VOLUME 16, NUMBER 4, APRIL, 1935

ON GLASSHOUSE REFRACTORIES

By W. L. FABIANIC
Owens-Illinois Glass Company

THIS paper[1] is a general discussion of glasshouse refractories. The merits and defects of refractory production, some causes of failure and the consumer's expectation of modern-day refractory products are viewed from a practical standpoint. A few of the more important properties of refractories are briefly discussed, but no attempt is made to cover the entire field. Tentative suggestions as to the customer's desires are expressed throughout the paper.

It is hoped that the paper will also contribute some information to the refractories manufacturers concerning the various conditions and usage to which their products are exposed, and better enable them to fabricate intelligently a product which will meet the conditions imposed upon it. A few years ago any refractory failure was blamed whole-heartedly on "bad block." No other reason for the cause of failure was sought and the particular defect in the inferior product was not even classified. Naturally the refractory manufacturer made little progress in improving his product. Fortunately, in recent years, due to the phenomenal advance in scientific investigation, increased demand on furnaces and the banishment of the cloak of secretiveness long surrounding the glass industry, the consumer and manufacturer of refractories are now meeting on a common ground. Information, problems and conditions are freely discussed to the great benefit of both parties.

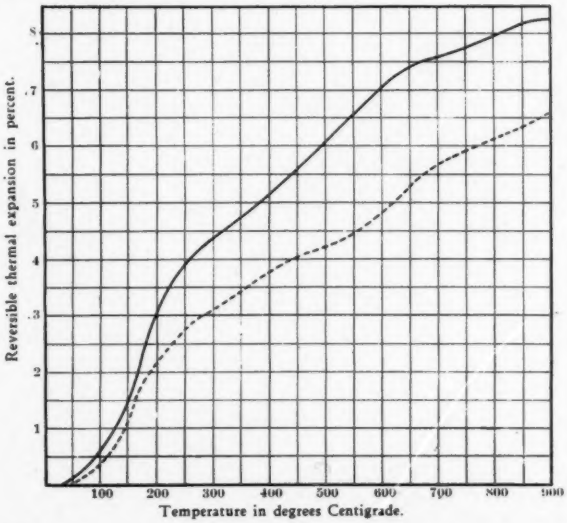


Fig. 1. Reversible thermal expansion of two different types of tank block.

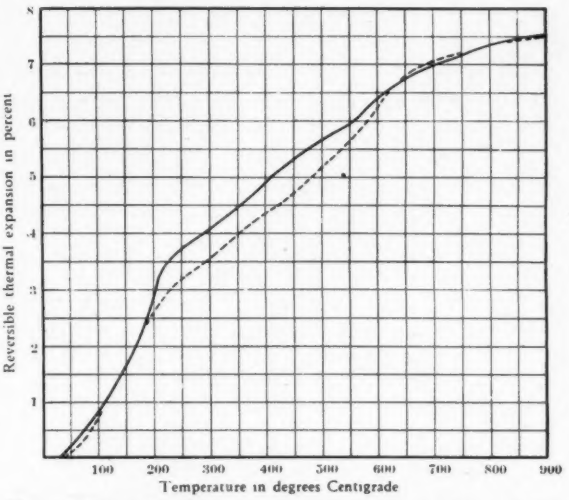


Fig. 2. Reversible thermal expansion of two pieces of the same brand and shipment. Note the difference in expansion in the middle of the range.

Specifications for refractories have been set up for most types of high-temperature furnace operation with considerable success, but this is not wholly true of glasshouse refractories. Consumers of glasshouse refractories attempting to select their refractories with the present specifications as a guide, have often come into considerable grief. There appear to be innumerable obstacles hindering the correlation of the standard tests with those of service.

In a final analysis, the ultimate factor in determining what refractory is best for a certain condition is the actual service given by the product, regardless of how admirably it fills a set of specifications.

The glasshouse consumer would like to have the refractory maker furnish him with a usable set of specifications. This means an intelligent technical investigation of all types of refractories and service conditions in each glass manufacturing field, with resulting specifications set up for each type, which will as near as possible be a measuring stick of the specific properties needed for the service to which it is to be subjected.

The author contends that the present set of specifi-

cations, excellent though they are, are so little used because they are too generalized. Individualized specifications are necessary due to the many different types of batches melted, furnace operation, fuels used, furnace design, dust conditions and many other variables. This is illustrated by the indisputable fact that several brands of flux block meeting the present general specifications do not give nearly as good service as other brands which meet only one or two of the standard laboratory tests.

The situation is not hopeless by any means and the consumer and producer of refractories are now cooperating so closely on this problem that it seems probable the near future will bring out a set of valuable specifications which can be correlated satisfactorily to practical service conditions.

Some Desirable Properties

Degree of Burn. One of the most important general properties of all refractories used in contact with the molten glass itself is that of being well burned. A

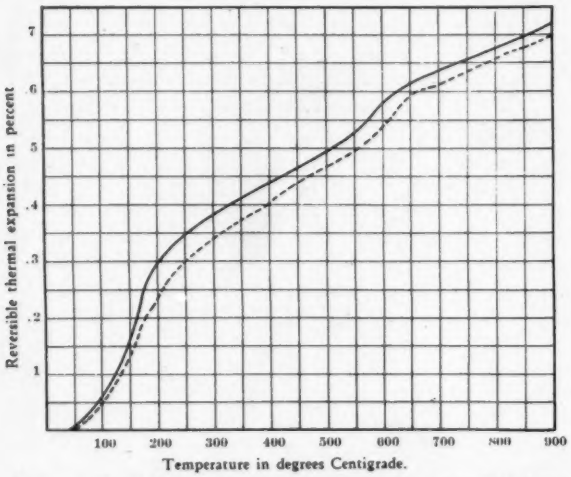


Fig. 3. Reversible thermal expansion of two blocks of the same brand but of different shipments. Block E (solid line) failed in service. Block F (dotted line) proved satisfactory.

well-burned refractory gives better service because of its lowered rate of solubility in molten glass, lower porosity, higher degree of vitrification and increased mullite development. It is realized that more pronounced heat treatment raises the production cost and thus increases the price of the product. With the glass manufacturer, however, the initial cost is relatively unimportant. It is the final cost per unit of product, uninterrupted operation, fewer repairs and better glass that the glass maker wants, and if a high initial refractory cost will insure these things, no objections will be raised.

Uniformity of Product. A product uniform as to size, weight and composition is much to be desired. Warped flux block mean poor joints and increased rate of wear.

In general, most present-day first-grade firebrick are of uniform size and weight. This does not apply to super-refractory brick of the high alumina class. Brick from the same shipment will exceed the permissible limit in dimensions and vary over one-half pound in weight.

Patched jack arch block are still a common occurrence. The consumer objects to receiving such block when they show plainly they have cracked during some stage of manufacture and have been patched. In service the blocks invariably fail at the point of repair.

Constancy of composition of the refractory mix appears to be very important, especially in such products as plugs, troughs, needles, orifice rings and sleeves. These products suffer from periodic intervals of bad failures, due to the refractory mix having been changed and an inferior product unwittingly produced. The refractory manufacturer should well consider the effect the glass may have on any product into which new raw materials are to be introduced, and not make the consumer pay for his experiment.

Thermal Expansion. Another desirable property of glasshouse refractories, for use both above and below the glass level, is a uniform and controlled expansion. Whether unequal expansion in a product is due to variances in composition or to the different degrees of burning received in various parts of the kiln, the final result is untold grief for the consumer. An examination of a few expansion curves made on commercial shipments of refractories during the past year will eliminate the need of a detailed discussion.

Fig. 1 shows the great difference in expansion encountered in two present commercial brands of block of the same type and similar in composition.

Fig. 2 shows the expansion curves for two block of the same brand and shipment. They have the same total expansion, but note the different rate of expansion between 190°C. and 625°C.

The expansion curves in Fig. 3 illustrate a difference in both the rate and the total expansion of blocks of the same brand. These block caused trouble. Block "E" failed in service due to excessive cracks and checks formed during the heating-up period. Block "F" proved to be satisfactory.

The detrimental effects of excessive cracking or spalling in half of tank block have been exhaustively discussed in previous literature and need not be reviewed here. All commercial block are subject to some extent to horizontal cracking. Some blocks have such a high expansion in service conditions that wherever they con-

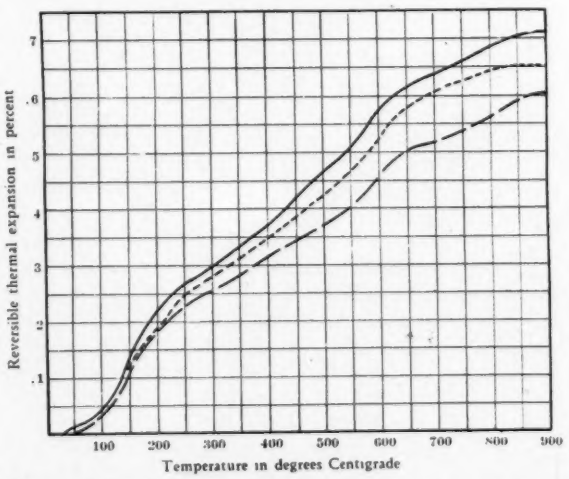


Fig. 4. Reversible thermal expansion of troughs used with revolving pots. Sample A (solid line), B (dotted line), G (dash line).

[1]Copyright, American Refractories Institute, Pittsburgh, Pa. Reprinted by permission.

tact the ironwork of the furnace large radial cracks appear. Fig. 6 is a sketch of an actual case of such radial cracking. The mechanical spalls shown by the shaded areas crush off, and if inside the furnace, a period of stones will result. The author has seen the "I" beams supporting the bottom block almost completely rolled over, due to excessive expansion of the block. The true solution to the proper expansion may lie in working out the correct relationship between the thermal expansion values and those for thermal diffusibility, thermal elasticity and mechanical strength and then correlating the resulting information with the heating-up schedule for the tank.

Fig. 4 gives the expansion curves on some clay troughs used on the Owens Furnace through which the glass flows from the refiner into the revolving pot. Trough "A" checked at 225°F. and the end broke off before 1600°F. was reached. Trough "B" proved to be satisfactory but it had a lower total expansion than trough "A" and also a different rate at 200°F. The curve for

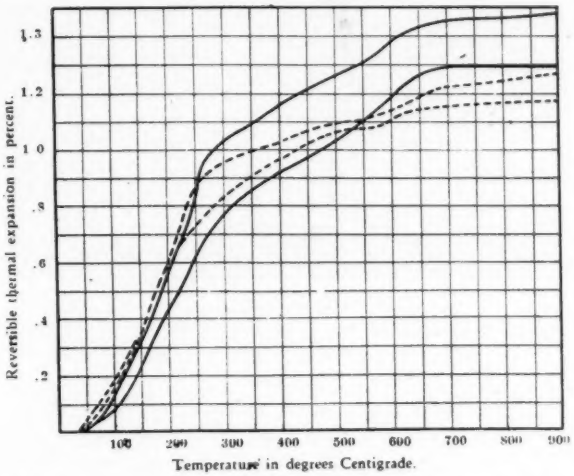
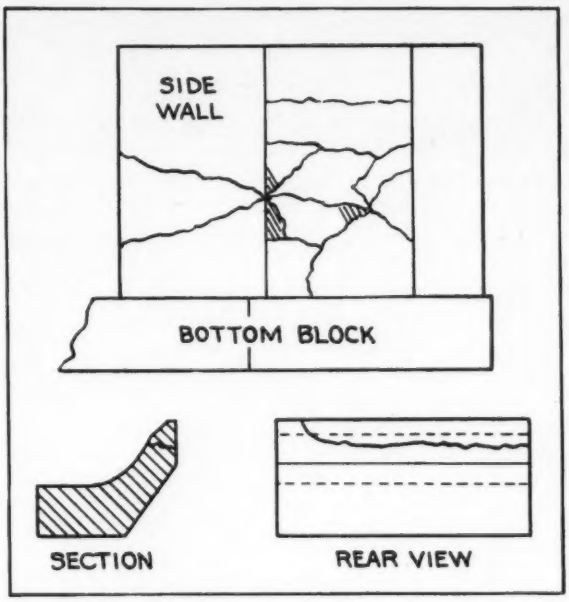


Fig. 5. Reversible thermal expansion of two types of silica brick. Dotted line is type A. Solid line is type B.

trough "C" shows the still lower rate of expansion of a soft-burned porous trough used for hot repairs.

Fig. 5 shows the actual variation secured in the expansion of commercial silica brick over a period of six months. Six silica brick made from Medina quartzite (Type A) were taken from the stock sheds over a period of six months and the corresponding expansions determined. The maximum and minimum expansions obtained are shown by the two curves designated as type "A". The same procedure was followed in the case of six silica brick made from Baraboo quartzite and these two limits expressed by the two curves designated as type "B". It would seem that this is too wide a variation for commercial silica brick. As a rule, silica brick of close texture with maximum burning to secure high inversion of quartz to cristobalite to trydimite, giving great volume stability, are best for glass furnace crowns. It is open to question, however, as to just how much good such a brick will do the glasshouse consumer unless greater care is exercised in the early stages of heating up the furnace. It is almost a question of whether the amount of quartz conversion should govern the heating-



(Top) Fig. 6. Cracks which developed in service. Dark areas indicate pieces fallen out. (Below) Fig. 7. Dangerous type of horizontal cracking in a pot rim.

up schedule, or if the heating up should govern the amount of quartz conversion. Too low a percentage of quartz conversion will tend to raise the crown, causing mechanical spalling and cracking, which considerably shortens crown life. This is a matter for consideration, and perhaps specifications will have to recognize a silica refractory with both a high and a low percentage of quartz conversion, depending upon the service conditions to which it is to be subjected.

Nearly all pot-rim sections crack vertically with no apparent harm done. When the same brand of refractory under the same service conditions begins to crack horizontally around the rim it would appear that some property of the refractory had changed. The horizontal cracks cause failure, due to the upper section of the rim not being held mechanically in place, other than by the pinching action of the neighboring blocks. After the slice bar is used a few times the crack is widened enough to let the glass through and a new rim is necessary. Fig.

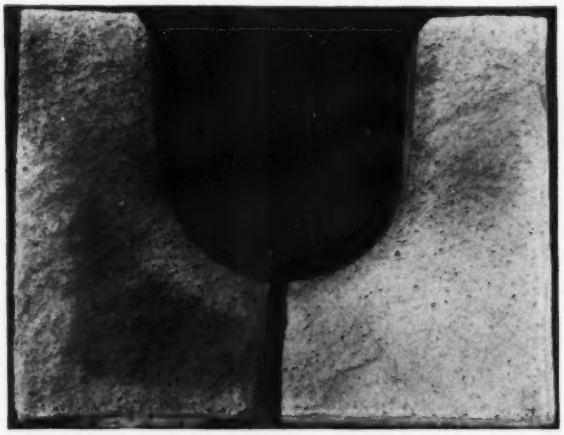


Fig. 8. (left) Section of trough that failed, and (right) one which gave good service.

Fig. 9. Pieces of foreign material found in a plug that failed after a short campaign.

7 indicates the dangerous type of crack in a section of pot rim.

Slagging. The question of slagging will be confined here solely to checker-work. The problem is, of course, very vital in connection with crowns, end walls, port jambs and sills, cover block, tongue walls and tuck stones, but it is felt that top checker courses are in more immediate need of relief.

Present-day checker brick requirements present a very difficult problem, and one which as yet the refractory manufacturer has been unable to solve. Silica brick, magnesite brick, high alumina brick, and first-grade firebrick have all been used in large-scale production.

Silica brick can be used for checkers, although great precaution is necessary in heating up the furnace. Their heat exchange value is somewhat higher than that of firebrick but their heat capacity is lower.

Magnesite brick have been used in checkers with doubtful success. If water is kept away from them and the dust is always on the alkaline side, they should hold up reasonably well. When the batch dust exceeds 20% in silica the magnesite brick seem to be attacked and destroyed very rapidly.

The high alumina brick have several disadvantages, the chief one being that the dust adheres to their surface without fluxing and the accumulated crust clogs the checker openings. The first-grade firebrick allows the dust to flux and drain away, but in so doing the brick itself is fluxed away so rapidly that the top courses are gone before the furnace campaign is over.

Bearing in mind the temperature of checker operation, amount and character of dust, method of cleaning checkers, type of fuel, furnace atmosphere and method of furnace operation, a brick should be fabricated having a high heat capacity and a rapid heat exchange value. It should not be as refractory as a high alumina brick and neither should it flux away as rapidly as first-grade firebrick that are now available.

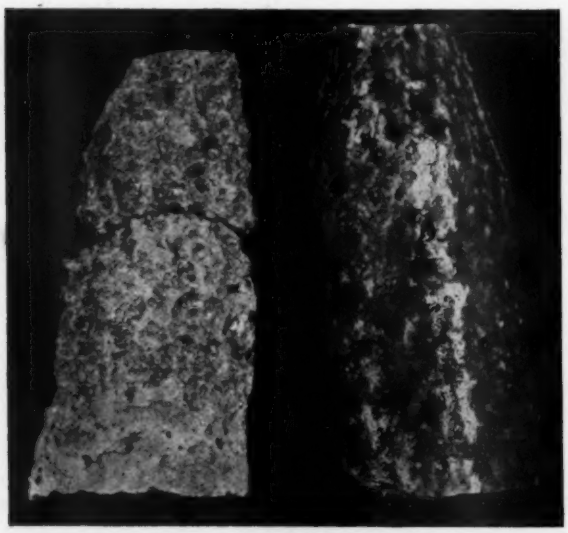


Fig. 10. Clay needles used in forehearth feeders. That on the left gave poor service and caused stones. The other gave good service.

Some Causes of Refractory Failures

There are many technical reasons for the cause of refractory failures, but it is not the aim of this paper to enter into a technical discussion of the subject. It was thought that the presentation of a few of the practical causes of failure would be of general interest.

Many refractory failures are the fault of the consumer as well as the manufacturers' product. Failure often results because the product was used in the wrong position under adverse conditions. Placing of refractories is important and the consumer should bear in mind that

Fig. 11. Sections of needles shown in Fig. 10. Note the differences between those in the transition layer. The section at the left shows foreign material.

the manufacturer has carefully worked out the screen sizes, blends, composition and various other properties of his product and that the resulting product cannot be abused if the best service is to be obtained.

Items Under Consumer's Control. It appears to be obvious that a dense hard-burned refractory should not be used for a hot repair, or that cold silica brick should not be introduced into a hot furnace. At times, inexperienced foremen violate the fundamentals of good practice by blindly trying to follow out some previously accepted plant procedure without making allowances for some new or changed condition.

Great injury is often done good refractories during the early stages of the heating-up period. Most of the mechanical spalling, both of block and crown, occurs below 600°C. Greater care should be exercised during this period and the heating-up schedule more closely correlated to the expansion curves of the refractories.

Defective pyrometers sometimes cause tanks to be operated for long periods at temperatures close to their fusion point. This condition considerably shortens the life of the refractories.

Sometimes too large an expansion joint is left between blocks. This is nearly as bad as too little room, as the glass will enter such a joint and attack the block from the sides as well as the front. In connection with this it might be mentioned that improper attention paid to letting out and taking up the tie rods is a common cause of shortened refractory life.

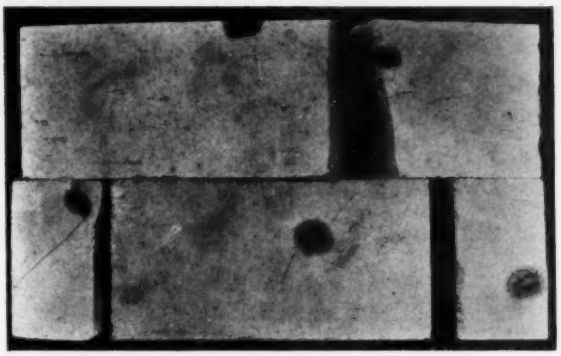


Fig. 12. Premium-priced super-refractories containing iron spots.

Other factors under the control of the consumer which are often neglected are: too low a furnace crown; insufficient draft; velocity of gases, length and nature of flame; changing glass level; dirty cullet; foreign iron; improper cooling wind; insulation of refractories by improperly-placed iron work; and neglect of preliminary heating up of certain products such as troughs and feeder parts.

Jack arches over revolving pots fail a great many times because the machine has struck and grooved them. These arches also drop down due to improper attention to expansion rods during weekend shutdowns. The temperature is sometimes dropped from a high to a considerably lower temperature within a short time and no attention paid to taking up tie rods. As a result the arch contracts and gradually drops down and falls out.

Items Under Manufacturer's Control. It is surprising how many refractory failures are caused by obvious defects in the product which the manufacturer should catch but does not.

Fig. 8 shows the reason for a very costly series of trough failures over a week's period. The photograph is of half a cross section of both a good and bad trough. The half in the left of the picture illustrates the source of the trouble. The defective troughs all had a large unoxidized core extending through their center portion. Upon reaching 300°F. the ends checked and an increase in temperature caused them to fall off in the revolving pot. The cross-section in the right of the photograph shows a well-burned trough which gave satisfactory service.

Fig. 9 shows a plug that failed after a short campaign. A post mortem showed it to contain three large pieces of foreign material as illustrated in the photograph. This was pure carelessness on the part of the workman making the plug.

Fig. 10 shows two clay needles used in forehearth feeders. The needle on the left was made of inferior material and poorly bonded. As a result glass attack was severe and the grog particles in it washed out, causing stones in the ware. Note the difference in its surface with that of the needle shown in the right of the photograph. The defective needle also eroded away off center from its axis, while the good needle wore evenly about its center. Fig. 11 shows the difference in the transition layer of these needles. The defective needle has a much thicker and jagged transition layer than the good one. The cross-section of the needle shown in the extreme left of Fig. 11 shows a large piece of foreign material occluded in the needle. When tapped gently with a hammer, the needle parted at this point.

Shelling off is a characteristic failure of hand-made plugs. Examination of a typical failure showed that it was full of lamination planes, and failure had occurred along one of these. It would seem desirable to produce a power-pressed plug.

A very pronounced case of iron spots in a super-refractory brick is shown in Fig. 12. These pits are from ¼" to 1¼" in diameter and were all plainly visible to the packer. The consumer feels that when he pays a premium price for such brick that he should get hand-picked ware and that such obvious defects should be caught by the manufacturer before shipment.

It is hoped that comments pertaining to the various desirable properties and causes of failure of some of the refractories used by the glasshouse industry will be of some value both to the producer and consumer.

This paper has not mentioned any important phases of glasshouse refractories problems, but it is hoped that those discussed will stimulate thought on the subject. The clearer the conception obtained by the maker of refractories of the consumer's wants the closer they will approach the solution of the ever-present refractory problem.

PUBLICATION

Determination of Mean Specific Heats at High Temperatures of some Commercial Glasses. Bulletin No. 271 of the Engineering Experiment Station, University of Illinois. By C. W. Parmalee and A. E. Badger.

Although numerous determinations of the specific heats of various types of glass have been made in the past, the results apply usually to the lower regions of temperature where glass exists in the solid state. This bulletin contains an account of the results of measurements of the specific heats of some important types of commercial glass in the molten state.

A study of the specific heat of glass is of theoretical interest in that its variation with temperature may serve to indicate polymetric transformations occurring in glass at different temperatures. If such transformations occur in any temperature interval, they would be apparent from measurements made at smaller steps within this range.

In the investigation described, some attempts were made to determine whether transformations take place in the temperature interval between 800 and 1050°C., but the precision of the method employed was not sufficient to permit of definite conclusions being drawn as to their presence.

Specific heat measurements have the practical utility of affording the means of predicting the fuel requirements in certain stages of the manufacture of glass.

PLATE GLASS MAKES FURTHER GAINS

Total production of Polished Plate Glass by the member Companies of the Plate Glass Manufacturers Association for the month of February was 13,723,151 sq. ft., as compared to 13,365,188 sq. ft. produced the preceding month, and 7,441,278 sq. ft. produced in the corresponding month last year, February 1934.

FORD TO SPEND $3,000,000 MODERNIZING BATON ROUGE

The Ford Motor Company is making preparations to install new glass manufacturing equipment in the glass factory at the Rouge Plant and is expected to resume glass manufacture next winter. The cost of the project will approximate $3,000,000.

Ford, the originator of the "continuous" process of glass manufacture now general throughout the industry, has not engaged in glass manufacture at the Rouge Plant for the last three years. The original equipment installed for the "continuous" process, is now being moved out of the glass plant to make way for the new machinery.

When the installation is complete and glass manufacture is resumed, the glass plant will employ an additional 1,000 workers. The glass plant is now engaged in the production of laminated "safety" glass, utilizing glass supplied by outside manufacturers, 1,400 men being employed in these operations. The new installation will provide only sufficient capacity to supply a part of the company's glass requirements.

The new "big unit" will comprise twin 600-foot lines including melting furnaces, annealing furnaces, grinding and polishing machines capable of producing 90-inch wide ribbons of one-eighth inch plate glass at the rate of 150,000 square feet every 24 hours.

Glass will be produced in two great 75-ton melting furnaces, one of which will head each section of the line. Molten glass running from these will be rolled into continuous ribbons up to 90 inches wide and then passed through annealing furnaces, fitted with modern electric heaters, before being cut into the desired lengths for grinding and polishing. Each line will have 60 grinders and 100 polishers.

One of the new melting furnaces and its companion "lehr" have already been installed. Preparations are under way for the installation of the second melting furnace and the other equipment.

BUSIEST YEAR IN HISTORY FOR LYNCH CORPORATION

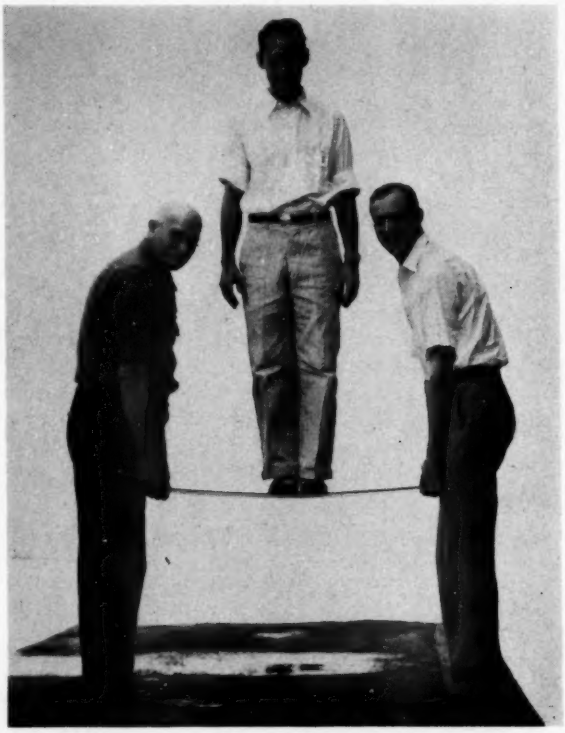
Lynch Corporation, Anderson, Indiana, reports a net profit for 1934 amounting to $290,574.13, after deducting expense items of nearly $20,000 incurred in moving into their new plant and more than $50,000 depreciation. Surplus was increased by $35,000 after absorbing losses from the sale of the old Anderson factory, writeoffs in the valuation of the Columbus plant, and payment of a $2.00 dividend on 90,000 shares of stock. Lynch Corporation has no funded debts, no loans and no preferred stock.

RELATION BETWEEN COMPOSITION AND PROPERTIES OF GLASSES

A number of experimental glasses containing soda, alumina, and silica were melted in platinum and analyzed. The index of refraction, density, and thermal expansion of the glasses were determined and graphs prepared to show the changes in the properties mentioned with changes in composition. From these graphs which have been published in the Journal of Research for February (RP762), it is possible to predict the refractivity, density, or expansivity of any glass in the range of compositions studied.—*Technical News Bulletin*, Bureau of Standards.

THE DARING YOUNG MAN ON THE FLYING TRAPEZE

This picture shows an informal test of a hardened glass windshield prepared by the Pittsburgh Plate Glass Company. This is a regular Chrysler windshield, of ¼" plate glass hardened by sudden quenching in air-blasts from a point just short of softening. While ordinary (annealed) glass would break under a much smaller load, the hardened glass would stand a great deal more than is here applied. The test was made at Butler, Pa., by the staff of F. W. Preston. Left to right: James Carrie, master mechanic; George McKee, chief draughtsman; Frank Preston, glass technologist.



The test object (George McKee) is an aviator, so he's used to being all up in the air, but he says he doesn't like being without visible means of support. After he got through, the others tried it out. Mr. Carrie weighs 210 pounds and his weight buckled the glass into all sorts of shapes, but did it no harm.

Note that this is not "safety" glass in the sense of "laminated" glass. Laminated glass is weak, often much weaker than an ordinary sheet of ¼" plate. Its "safety" feature does not lie in its being strong or unbreakable, because it breaks very easily; but in the fragments being held by the gum or celluloid layer after breaking.

Incidentally, Mr. McKee had his throat cut from ear to ear by a piece of *laminated* "safety" glass in an automobile accident after the picture was taken. The assumption is of course, that the accident would have been worse, possibly fatal, with unlaminated, annealed, glass.

IMPROVEMENTS IN REGENERATIVE FURNACES

By W. A. MORTON

REGENERATION for industrial furnaces was invented about 75 years ago and has been improved periodically to meet the incessant demand of progress. These changes deal with various parts of the furnace, burners, and furnace auxiliaries; yet it can be truthfully stated that no concurrent important improvements have been made.

The first epoch was marked by the conception of the reversing principle, followed by practical experimental work with the checkers, valves, ports or application of fuel, correct furnace proportions, hearth elevational considerations, and other details. Succeeding epochs, if we judge from the vast variation in the present day operation and efficiency of these furnaces, have been devoted largely to retracing these experimental steps subsequent to the determination of the basic principle.

Many of these variations are due to lack of a sound comprehension of the basic principles involved, or an unwillingness to fully recognize the limitations of prime factors in adapting the furnaces to varying environments.

Environment, load, preheating surface or checker arrangement and fuels are inter-related factors in that they produce variations in the over-all efficiency of regenerative furnaces. Environment established by a purchaser, such as elevations affecting hydrostatic pressures, influence efficiency and production and very frequently create an unsatisfactory unit, although all the other parts may be sound and comparable to those of a successful furnace. Such variations in elevations require compensating checker settings, port resistance, burner setting or port inclination: the *checker setting*, to provide proper area for air delivery by avoiding excessive pressure drop where pressure must be created; *port resistance*, adequate for the delivery of the required weight of gas and air at practical velocities; *burner placement*, to confine the combustibles for variable intervals of time and space to compensate for lean or rich fuel burning at the particular velocities available; *port inclination*, adapted to the available head and character of work to be done.

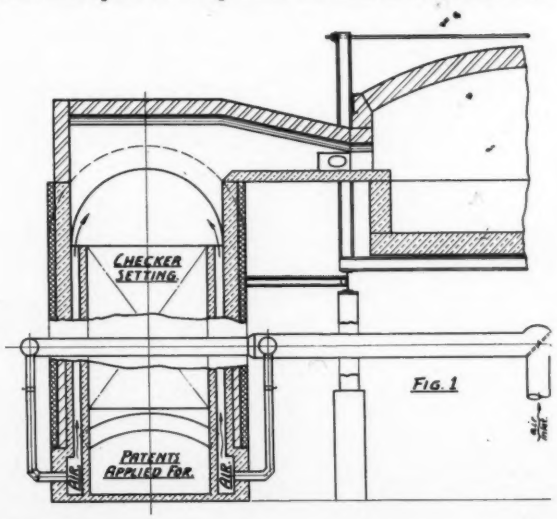


FIG. 1

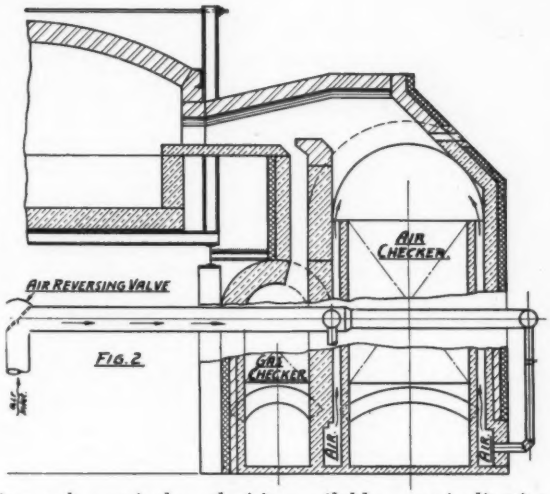


FIG. 2

The load factor, when affected by environment alone, may vary between 50 and 100 per cent because of inadequate pressures. Adequate pressure is essential to impress the port velocities required for mixing and directing the combustibles to the hearth.

The preheating surface is determined by the weight of air to be heated for the particular fuel to be burned. The checker heating surface area required for air only, for the burning of natural gas, is in the ratio of approximately 9 to 7 to raw producer gas. The nature of the setting, as to flue sizes, will obviously vary if we assume that the furnaces vary only in potential hydrostatic pressure. The shorter distance between flue and port sill precludes a more open setting of checkers to insure the delivery of the required quantity of air by the lower available head.

Assuming the influence of environment on operation to be a factor of consequence appreciated by some designers, we pass to the discussion of various recent improvements in the order of their interest.

Regenerative furnaces are used for a wide variety of high temperature melting or heating operations. Fluxes used in melting furnaces, such as for melting glass, silicates of soda, or in open hearths for steel, etc., reduce the refractories forming the checker setting. These fluxes form various chemical combinations which tend to clog the checkers and gradually impair the efficiency of the furnace. A simple improvement is illustrated in Fig. 1, which shows a way of effecting constant delivery of air to the burner ports of the regenerative furnace. If we assume that the available chimney draft at the base of the checkers during the passage of waste gas is half an inch of water and that the theoretical head for delivery of air on reverse is a quarter of an inch of water, the practicality and necessity of compensating for the gradually clogging of the regenerators to insure delivery

of air is quite apparent. The force available for exhausting waste gases is shown to be about two times that for the air, but the ratio of the weight is approximately only 85 to 75. It is obvious that the waste gases will be exhausted from the furnace long after the delivery of air. Delivery of the desired quantity of air at all stages in the campaign of the furnace has heretofore been assured only by the use of fans (power) to drive through the checkers—a common but expensive expedient—or by resetting the checkers with a loss of production. This measure is resorted to frequently during a single campaign with some furnaces.

Fig. 1 reveals a hollow wall with ducts forming the sides of the regenerators with dampered reversing air inlets to control the delivery of air to the free space over the top of the checkers, and to collect the heat stored in the walls and the roof. During the removal of waste gases, these ducts are inactive and form a dead air or insulating space. The construction provides means to control the roof temperature of the regenerators, which frequently are over-heated during very high temperature operations. This control will redistribute the heat in the checker setting, protect the roof and side walls, and may be used as an auxiliary air delivery system for the furnace until the final preheat temperature falls below that at which the continued use of the furnace becomes impractical and checkers must be reset.

This auxiliary means for supplying air to the furnace has a two-fold purpose: It is an effective means to bypass air to the furnace without heat losses; it becomes an efficient low cost insulated type of wall. The value of insulation on furnaces is so generally conceded that its use is almost universal.

The air and gas valve controlling separately the quantities of air and gas to each side of the furnace were important improvements. Most industries use only the dual air control.

About 10 years ago, port designs were given much attention and various complicated types were evolved, most of which have been abandoned for the sake of simplification. Ports have taken on a very specialized form for particular fuels, supplanting the earlier inefficient all-purpose port.

There are available today improved refractories which extend the life of furnace linings. A method of expanding the length of efficient service of the checker has now been discovered. A few regenerative furnaces have ports that produce flames with higher radiation power by means of delayed combustion; this is more generally termed "luminous burning". Fig. 2 shows another noteworthy improvement for the regenerative furnace burning raw producer gas, which is not in general use. This involves the use of a smaller than conventional gas regenerator, which not only avoids "cracking" the hydrocarbons in the gas but also reduces the quantity of fuel lost during reversals of the furnace. A reduction in the temperature of the gas regenerator saves additional fuel which would otherwise be required for supplying radiation losses. In a particular instance where this simple improvement was properly applied, a fuel saving of over 20 per cent was made, together with a marked reduction in installation cost. The practical application of this principle during the past few years and its direct use on recuperative furnaces has proved that preheating of raw producer gas fuel for most purposes is not only needless, but may be decidedly wasteful.

In conclusion, it may be stated that each of the two features considered in Figs. 1 and 2 present an opportunity to effect economy, and are of such form that they may be applied to most existing furnaces without risk. The operator who has worried with clogging checkers will immediately see the relief afforded by the principle outlined in Fig. 1. The manufacturer will grasp the immediate possibility of balancing the life of all parts of the furnace to insure uninterrupted performance at maximum rating. This is important, now that repairs to furnaces are made biannually instead of every year due to improved refractories.

PROFESSOR W. E. S. TURNER IN AUSTRALIA

Professor W. E. S. Turner accompanied by Mrs. Turner has been spending the winter making a round-the-world tour. He left Sheffield, England, just before Christmas, crossed between the Americas via the Panama Canal, and was next heard from in New Zealand the end of February. From there his plan was to visit Australia and return to England via South Africa. He is expected home early in May. Last reports indicated that Professor Turner had improved greatly in health as a result of his vacation and he expects to return to his work with renewed vigor.

ACCIDENTS IN GLASS FACTORIES DUE TO POOR LIGHTING

Glass ranks tenth in a list of 17 industries having an accident record due to poor lighting. So reports Charles D. Poey to the Illuminating Engineers Society, as the result of a survey he made in 1249 cities and 36 states. In another compilation, Mr. Poey places glass making as thirteenth among 18 industries ranked in the order in which modernization of lighting equipment is needed. Of all the factories surveyed, nearly 85 per cent use obsolete reflecting equipment, notably the paint and varnish and canning industries.

GERMANY USES SAFETY GLASS

Several different kinds of safety glass or substitutes are being offered in Germany to replace plate or window glass for use in automobile bodies, with a view to eliminating the dangers of broken glass in the event of a crash.

"Artificial glass" is a glass substitute possessing greater elasticity than silicate glass and does not sliver under any conditions.

A single layer of non-laminated safety glass is known as Securit. This consists of a sheet of plate glass which after having been brought to its final form is heated in special ovens to near its softening temperature and is then rapidly cooled.—*Allgemeine Automobil Zeitung*, Aug. 25.

Plate glass requirements of the automotive industry increased 20 per cent in 1934 over the previous year. The Pittsburgh Plate Glass Company estimates a further increase of 10 per cent for 1935.

REPAIR OF NOBLE METAL THERMOCOUPLES

IT IS being increasingly recognized by progressive glass manufacturers that the efficiency of their process and the quality of their product is to a great extent dependant upon accurate temperature control, especially in the high temperature regions of the process. The net result has been that the use of noble metal thermocouples in the high temperature range of the process has increased and accordingly their use is no longer confined to a single position in the crown as was the practice in the past. For example: it is not an uncommon sight to see several noble metal couples in use on a single furnace in locations such as the dog-house, throat, downtakes, side walls and at fixed points in the crown.

The intelligent use of such couples requires that they be constant in calibration. While the couples are constructed from pure platinum and an alloy of platinum and rhodium, both of which are metals that are very resistant to deterioration, continual use in service will cause changes in calibration. These changes are due to the oxidation of the wire, contamination by the furnace fumes and to physical changes in the wire itself.

The deterioration of the wire usually causes the emf of the couple to decrease with the result that as the deterioration increases the couple will give readings that are increasing lower. It is therefore essential in installations where accurate temperature measurements are necessary (e. g., in control work) to frequently re-check the thermocouples being used.

In plants using a large number of couples it is often the practice to employ a special man whose work consists of the one job—the maintenance of the pyrometric equipment. In smaller plants where few couples are used the plant electrician is usually responsible for the equipment. In either case a regular schedule of standardization should be followed by the man in charge. Where extreme accuracy is essential or in cases where the couple is exposed to conditions such as extremely high temperatures or the couple is unprotected, every couple in use should be standardized at least once a week. In most cases a re-check once every month will usually suffice.

The equipment necessary for the checking and repairing of noble metal thermocouples is comparatively inexpensive and consists of the following:

1. Accurate potentiometer or milli-voltmeter, range 0 to 50 mv.
2. Standard platinum-platinum-rhodium thermocouple (18 to 24″ long)
3. Electric tube or muffle furnace
4. Ampmeter (A. C., 0.25 amp.)
5. Voltmeter (D. C. 100v.)
6. Rheostat
7. Thermos bottle
8. Pure platinum wire (6 to 12″ long)
9. Pure platinum-rhodium wire (6 to 12″ long)

A practical and simple checking procedure for noble metal thermocouples is as follows: the thermocouple is removed from its protecting tube and the wire washed in 50 per cent hydrochloric acid, washed in water and then dried, after which it is subjected to an annealing process. The purpose of this annealing is to eliminate the emfs which would develop if the wire contained hard and soft spots, in addition to removing any possible surface impurities.

Annealing is accomplished by suspending the couple between two binding posts and passing sufficient current through the wire to raise its temperature to about 1500° C (Fig. 1). A couple made from wires of 0.6 mm. dia. will require about 15 amperes and a 4 mm. wire will require about 10 amperes. During the annealing process it is often possible to see the contaminated sections of the wire as these portions do not glow as brightly as those that are purer. If the wire is not very badly contaminated the dark spots will gradually disappear and the entire length of wire will appear of the same color. The annealing is usually carried out for a period of 30 to 60 minutes depending upon the degree of contamination.

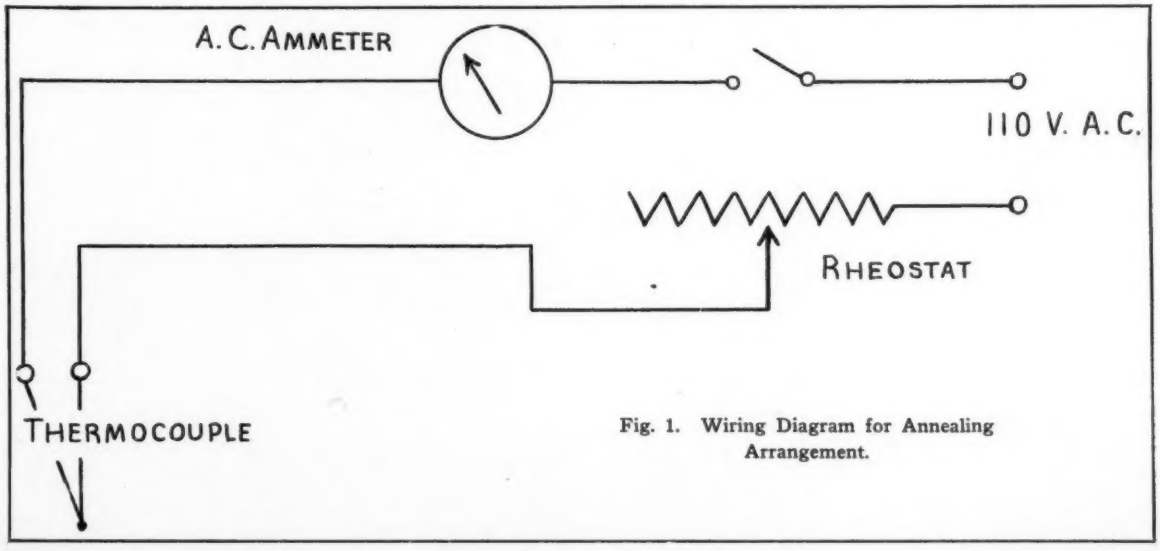


Fig. 1. Wiring Diagram for Annealing Arrangement.

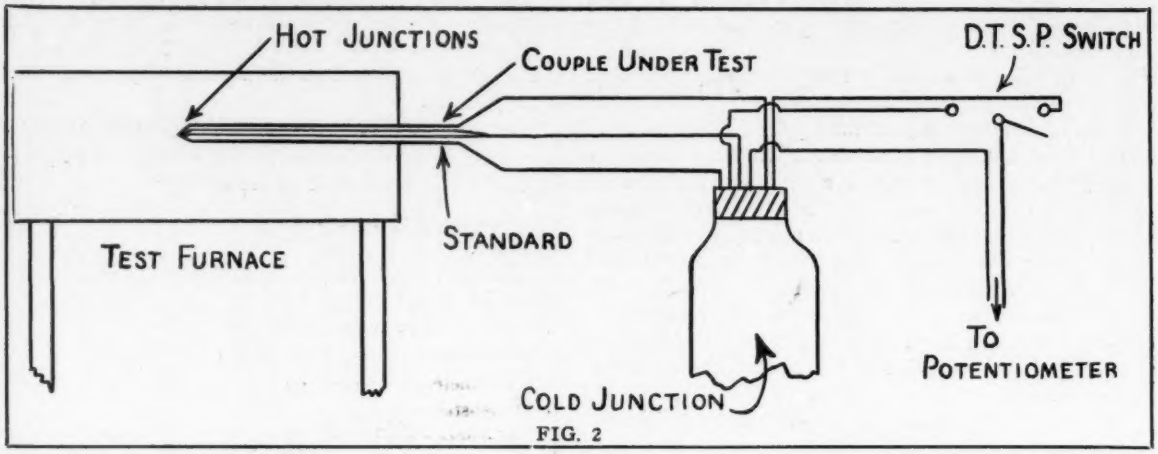


FIG. 2

After annealing, the hot junctions of the standard couple and the couples under test are tied together with asbestos string and the bunch inserted into the testing furnace. Compensating lead wires are connected with the couples and are then extended into a cold junction, consisting of an ice filled thermos bottle (Fig 2). By the means of a single pole double throw switch, the readings of the couples may be quickly taken at any furnace temperature. With a little practice it is possible to so regulate the furnace that a series of readings may be made while the furnace is building up in temperature. Needless to say all readings should be double checked at each temperature. By the use of a millivolt-temperature chart the millivolt readings of the standard couple are converted into the corresponding temperature readings and the millivolt readings of the couple under test plotted against these temperature readings. In this manner a millivolt-temperature chart of the couple under test is prepared.

If the tested couple is in error beyond the permissible amount (depending upon the degree of accuracy required) and excessive contamination is suspected the thermocouple is then subjected to a homogenity test. In this test it is necessary to have two short lengths of uncontaminated wire; one length of pure platinum wire and one length of pure platinum-rhodium wire. One end of the standard wire; for example the platinum wire, is placed in contact with a section of the platinum wire of the couple. This junction is then heated with a small bunsen flame (Fig. 3). If the wire is not homogeneous at this region the galvanometer needle will deflect, indicating the development of an emf. If there is no deflection of the galvanometer, the point of contact is moved to another position and the junction again heated. This procedure is followed until the entire length of the platinum wire is explored. The same procedure is then followed with the pure platinum-rhodium wire and with the platinum-rhodium section of the thermocouple. If any section of the wire shows a deflection of over three scale divisions on the galvanometer the section is cut out. The good sections of the wire are then welded into one length by the means of an oxy-acetelylene flame or an electric (carbon) arc. (No confusion should be experienced due to there being the two types of wire, since the platinum wire, being much softer, is easily distinguished from the platinum-rhodium wire). After welding the hot junction of the reclaimed couple it is annealed for a 60 minute period. The usual calibration with the standard couple is then made and a millivolt-temperature chart prepared.

The adoption of such a procedure will soon repay for the time and trouble expended as it will materially increase the life of the couples and insure accurate performance.

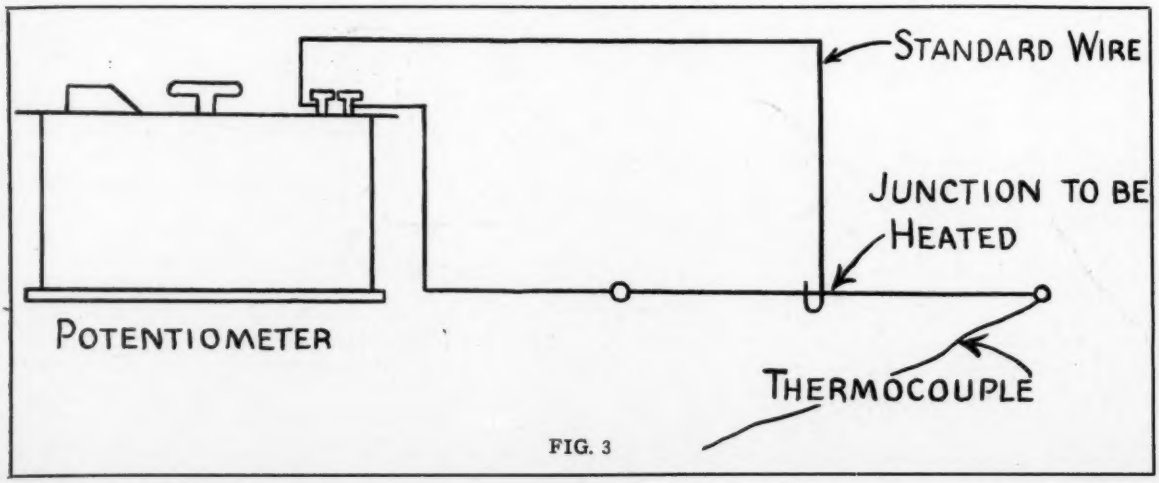


FIG. 3

VOLCANIC ASH AS A CONSTITUENT OF GLASS BATCHES

IN CERTAIN European countries, notably Germany and Russia, it is common practice to use natural rock materials such as trachyte, phonolite, nepheline, etc. as constituents of the glass batch. As such rocks are either high in alkali or alumina content a considerable saving in batch cost is the result, but due to the high iron content of these rocks they are not suitable for flint glasses and their use is naturally confined to the darker colored glasses.

In the United States little or no advantage is taken of such cheap natural glass forming materials. This is possibly due to the fact that this country has more or less made a specialty of the flint type of glass. The increasing use of light green and the very dark green glasses, especially in the liquor trade, may warrant an investigation into the possibilities of such materials.

One natural material that seems to have good possibilities in glass making, especially for those having plants in the Southwest and the West is pumicite. Pumicite is a powder or dust made up of small, sharp angular grains of volcanic ash. Its method of formation is through the violent and explosive eruption of volcanoes. While erupting, the volcano expels this natural glass dust in great clouds which travel across the surrounding country side and in time settles and forms a bed of pumicite. These deposits of pumicite are known to vary from a few inches up to 100 feet in depth. The grain size of the material depends largely upon the distance of the bed from the original source, the coarsest material being found nearest the volcano.

The extinct volcanoes of the Rocky Mountain range are responsible for the extensive pumicite beds found in the southwest and western parts of the country. Good commercial deposits of pumicite are to be found in the following states: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, Oklahoma, Oregon, South Dakota, Utah, Washington and Wyoming. At present the greatest production of pumicite is from Nebraska and Kansas although its production in California has greatly increased.

Considering the chemical analysis of native pumicite given in Table I, if the iron and moisture content are neglected it can be seen that they do not materially differ from the analysis of certain alumina silica glasses, except that the alkali content is very low. If, however, 20 parts of Na_2O is added, for example, to 100 parts of the ash marked No. A, a glass having the following composition will be obtained: SiO_2, 61.9%; Al_2O_3, 13.3%; Fe_2O_3, 0.7%; CaO + MgO, 1.7%; R_2O, 22.3%. The resulting glass is very similar to the high alumina glasses now being successfully worked in various parts of Europe. In fact, L. Romantcha[1] in a recent article records the successful use of pumicite as a glass raw material in two Russian glass plants. He also states that its use materially reduced the alkali requirements of the glass plant and that the resulting glass required higher working and annealing temperatures due to its high alumina content.

The high alumina content of the pumicite may offer distinct possibilities as a source of alumina in colored glasses. Assuming that the average alumina content of American pumicite is about 14 per cent, the addition of 100 pounds of this material to the ordinary soda lime glass batch (sand, 1000; Soda Ash, 380; Burnt Lime, 110) will give an alumina content in the glass of well over 1 per cent.

The disadvantages of pumicite in general seem to be: 1. Its use must be confined to glass plants close to the source; 2. Its high iron content excludes its use in glasses other than those which are highly colored; 3. Care must be taken to prevent large losses of pumicite from the batch due to its fine grain size and low density. Its main advantage lies in the fact that very low cost glass can be produced through its use.

Table I. Analysis of Volcanic Ash (U. S. A.)

	A	B
SiO_2	71.80%	73.44%
Al_2O_3	15.48%	13.68%
Fe_2O_3	0.80%	0.98%
CaO	1.42%	1.24%
MgO	0.53%	0.57%
K_2O } Na_2O }	5.89%	5.91%
H_2O	4.08%	4.18%

[1] L. Romantcha; "Glass from Volcanic Ash", Keramika i Steklo, 1931, 5, 32.

TO BUILD FILLING STATIONS OF TILE AND GLASS

The Austin Co. of Cleveland has been commissioned to design and construct a chain of service stations for the Ohio Oil Co., Findlay, Ohio. Bright red and white porcelain enamel exteriors with uniform metal and glass type construction will provide a maximum visibility from the roadside as well as from within the stations. Provisions for service and comfort include a spacious lubritorium where the patron will be able to witness the servicing of his car without fear of brushing against greasy equipment.

The stations will cost about $100,000 and will be scattered through northwestern Ohio.

PITTSBURGH PLATE GLASS EARNS $2.68 PER SHARE

Pittsburgh Plate Glass Co. reports net profits for 1934 of $5,763,684, or $2.68 a share, on the 2,141,914 shares of common stock, against $3,993,934, or $1.87 a share, for 1933. Surplus account shows a credit of $179,012 for adjustment of security holdings, while reserves were charged with $354,988, representing costs and depreciation on non-operating properties.

Almost half of the school buses operated in the United States are now equipped with safety glass, either as required by state law or by official recommendation. There are 66,320 buses transporting school children daily.

POSITION OPEN: To a man between 22 and 35, who in addition to Ceramic training, possesses to unusual degree the faculty of observing accurately and interpreting correctly. Describe experience of any kind indicating this faculty. Address Box 23, THE GLASS INDUSTRY.

MORE "STOPS" THAN "GO'S"

An estimate has recently been made of the extent of use of luminous traffic signals in the United States, says *The Technical News Bulletin* of the Bureau of Standards. Based on reports from manufacturers as of January 1, 1934, the output of signal glasses has been as follows:

Green	116,700
Amber	88,400
Red	141,700
Total	346,800

The output of red glasses is 21 per cent higher than green, which can only be partly accounted for by the replacement of red for amber in the system of certain municipalities. The output of amber glasses is 24 per cent less than green. It is estimated that there are more than 29,000 intersections in the United States, with a probable average of 12 signal glasses per intersection. New York State and Pacific Coast cities account for most of the two color systems, while the rest of the country prefers three colors.

Hazel-Atlas Company, Wheeling W. Va., will shortly move their New York offices to the Woolworth Building. A large section of the twenty-sixth floor is being remodeled and redecorated for their occupancy, about April 8th.

SOCIETY OF GLASS TECHNOLOGISTS HEARS INTERESTING PAPERS

At the last general meeting of the Society of Glass Technology, held in Sheffield, England, the following papers were presented.

"The Analysis of Glass by the Treatment of Thin Film in the Autoclave". By A. R. Wood.

A glass blown into exceedingly thin film from a platinum alloy tube, had a thickness of only about 1μ and showed bright interference colors. In this form the glass exposed an extremely large surface to a liquid reagent.

Glasses ranging in soda content from 9 per cent to 22 per cent were treated in this form in the autoclave at temperatures up to 217°, that is up to pressures of 300 lb. sq. inch. Water and aqueous solutions of caustic soda, sodium carbonate, borate and phosphate, and calcium and barium hydroxides were used as reagents. The soda extracted was determined by titration. Various indicators were used. Methyl orange was the most satisfactory. Among the difficulties encountered were the hydrolysis of the silicates of calcium and magnesium and also the absorption by them of soda.

It was found possible to determine the soda content of any commercial window glass by treatment of the film with water for one hour at 200°. It was remarkable that this could be done while the film still retained much of its original form and sometimes some of its interference colors. The method was found to be accurate to 0.2 per cent of soda for window glasses; but to attain this accuracy it was necessary to follow the technique exactly and to use about 0.08 gm. of film in 50 ml. of water, filtering very rapidly to free the solution from contact with the solid silicates. The film should always be freshly blown.

"The Influence of Some Batch Constituents on the Color of Glass." By E. J. C. Bowmaker.

In certain experimental meltings in open sillimanite pots of about 1 lb. capacity it was found that the substitution of about 2 per cent of barium oxide for an equivalent amount of lime necessitated an increase in the selenium of about 30 per cent to decolorise the resulting glass.

It was also found that cullet and borax had opposite effects on color: a 30 per cent addition of the former required an increase of about 25 per cent of selenium, whereas an addition of borax in the ratio 40 lb. borax per 1000 lb. sand required a 25 per cent decrease in the amount of selenium used.

"An Investigation of Selenium Decolorising". By E. J. Gooding and J. B. Murgatroyd.

Following a critical survey of the literature on selenium decolorising, an investigation of the decolorising of soda-lime-silica glass by selenium had been made. The colors had been expressed quantitatively on the Lovibond scale.

Standardized melting and cooling conditions were worked out and a series of melts were obtained from which the effects of the addition of minor constituents on selenium colors were recorded. A number of the glasses were subjected to reheating and sunlight treatment.

As a result of these experiments a theory of the reactions occurring was proposed. The theory was that the iron in glass was present as ferric oxide which decomposed with increasing temperature to ferroso-ferric oxide with the loss of oxygen. The reaction was irreversible unless oxidizing agents remained in the glass. Selenium reacted with the ferroso-ferric oxide forming a ferrous selenide. Arsenic combined with ferroso-ferric oxide formed ferrous arsenate, which was ionized by the action of sunlight. Sunlight had no effect on selenium or selenium compounds in glass. At high temperatures arsenic also probably combined with selenium to form a complex which decomposed at about 700°.

LAMP PRICES REDUCED

Effective April 1, a reduction averaging 21 per cent in the list price of 60 per cent of all large incandescent lamps, has been announced by Gerard Swope, President of the General Electric Company. Popular household types have been reduced from a retail price of 20 cents to 15 cents.

"This price reduction," Mr. Swope explained, "extends still further the downward curve, which over a period of many years marks the trend of prices on lamps manufactured by the General Electric Company. Since 1921 the General Electric Company has been able to make 17 price reductions on its Mazda lamps, for a total decrease of 66 per cent from the average net prices of 1921."

SOME ASPECTS OF THE BELGIAN TREATY

INCLUSION of plate, laminated, wire and ground sheet glass into the Belgian Trade Agreement came as a complete surprise as well as a keen disappointment to the rolled glass industry. Details of the treaty were announced the afternoon of February 27. Only that same morning, word had transpired that glass would not be one of the items included in the treaty.

Attempts have been made to belittle the effect that the treaty would have on American glass. It was argued and intelligently, that Belgian exports are an inconsiderable fraction of the total plate glass produced in this country; that the only market for Belgian sand, not withstanding its excellence, is the Pacific Coast; and there was a good deal of uninformed talk concerning the rate of exchange acting as a secondary tariff barrier. Particularly in jobber circles, the effect of all this was to minimize the treaty's effects on the glass industry. But the producers did not see it that way. They see serious consequences—which even the words of the treaty themselves do not reveal.

For it must be remembered that the treaty with Belgium is a treaty with the whole world. The Reciprocal Tariff Act, under the terms of which this treaty was negotiated specifically provides that "any duties proclaimed by the President in a trade agreement entered into with any one country *shall apply to articles, the growth, produce or manufacture of all foreign countries, whether imported directly or indirectly.*" Apply that to the Belgium treaty, and it means the tariff on the items concerned has been reduced one third to a half to all foreign countries. Indeed, considering that the dollar has been devalued by the Administration, the tariff actually has been lowered further. The rolled glass industry is in bad shape as it is, and to turn part of its already depleted sales outlets to competitive foreign merchandise, seems to glass makers the height of folly.

That this last is the avowed and deliberate intention of the Administration, there is no gainsaying. An analysis of the treaty prepared by the Department of Commerce states specifically: "A number of products affected by the concessions granted to Belgium are used by the building trades . . . The reductions in duty provided in the Belgian agreement should introduce more flexibility in prices to the advantage of . . . the building industries in particular. Among articles of this type are plate glass, glass sand . . . "

That can only mean that the Administration is deliberately aiming to bring plate glass prices down through the completion of foreign merchandise.

Glass Sand.

Most of the domestic producers of glass sand are indifferent to the treaty. Belgium is the only country shipping silica sand to the United States, and in 1934 her total exports to this country were 21,889 long tons against a total domestic production that for the last four years has averaged 1,670,000 short tons and in 1929 reached 2,220,000. This comparatively small tonnage of an excellent commodity results from the fact that Belgian ships cannot profitably engage in a coastwise trade between our Atlantic and Pacific ports; but they can pick up profitable return loads from the Coast, and carry the sand there as ballast. Consequently, the freight rate on sand to Pacific Coast points is virtually nil. Western glass men, on the other hand, depend for their best sand on Nevada, where Senator Pittman is reported to own the deposits. Shipments from Nevada westward have to stand the cost of the heavy haul over the Sierras. By reducing the tariff 50 per cent, Belgium is placed in a position to do a nice buisness with Pacific Coast glass men, and apparently the only injured party will be the honorable senator from Nevada.

But consider the plight of the producer who recently wrote to The Glass Industry: "For some time past our company has been looking forward to reaching the Pacific Coast market by water, using the Mississippi to New Orleans and transferring to steamships going to the Pacific Coast. It was possible for us to meet the Belgium sand competition with a $6.00 delivered price; but in order to do this costs had to be cut to the lowest point. It would, therefore, be impossible to absorb the $1.00 advantage now given the Belgians."

Here is a case where an expanding American business has been seriously harmed by the treaty. How many similar instances exist of which no one will ever hear?

Belgium

Belgium exports more plate glass to the United States than any other nation. In 1934, her shipments totalled 199,227 square feet—almost all of it consigned either to New York or to one of the Pacific Coast ports: Los Angeles, San Francisco, Seattle or Portland. But the past performance of Belgium, during a time when she was trying to climb over a substantially built tariff wall, merits less consideration than her future potential. Belgium has an artificially maintained price structure that permits her a tremendous advantage over American manufacturers. In Belgium, both the price and the production of plate glass is rigidly controlled by an International Cartel. As a result, production has been kept down to a definite quota, which in 1934 represented 40 per cent capacity. From figures supplied by the Department of Commerce, the total production capacity of that country would be 4,569,400 square yards annually. Output by years has been as follows:

Belgian Plate Glass Production (sq. yds.)

1934	1,827,768	1931	2,042,000
1933	1,874,000	1930	2,921,000
1932	1,874,000	1929	4,565,000

Belgian methods of manufacture are on a par with modern U. S. factories. Her labor and raw materials are cheaper. But thanks to the price fixing arrangement maintained by the Cartel, she sells her glass locally at a price level and at a profit many times higher that this country would tolerate. These abnormally high profits in the home market make it possible for Belgians to do an

export business on the slenderest of margins, and thanks to the tariff reduction she is now on a competitive basis with American producers, for whom she can make the going extremely difficult.

Japan

The best informed opinion rates the Japanese out of the running for at least two years. Heretofore, Japan has never exported any plate, but on the contrary has been one of our best customers. She is, however, probably the world's leading producer of sheet glass, having won to that eminence from scratch in an amazingly short time. It is not known that she has any grinding plant; so her sheet glass will not benefit at present from the lowered tariff concessions. Not many months ago, she purchased a quantity of plate glass machinery in America, which is being delivered this month; but this was for small size glass and does little more than provide production for domestic needs. However, Japan is known to be planning expansion and if, as many believe, she will be entering the American market in 1937, previous experience has shown how devastating her competition may become.

Glass men will be interested in a short account of the glass industry in Japan which appeared last July (1934) in a circular issued by the Mitsubishi Economic Research Bureau. The circular was entitled "The Glass Industry in Japan (with special reference to the sheet glass industry)", and states in part:

"The glass industry in Japan has become very active of late, both exports and production increasing. The most important glass product in this country is sheet glass which accounts for about 40 per cent of the total production in value, followed by glass bottles, table glassware, and ornamental glassware.

Production of Glassware (in 1,000 yen)

	Sheet-glass	Glass bottles	Table glassware	Ornamental glassware	Total*
1930	15,427	14,755	2,871	1,833	40,584
1931	15,033	10,927	2,455	710	34,389
1932	14,171	11,195	4,415	1,415	37,233

*Including others

"The more recent production figures of glass manufacturers are not available at this time (July 1934), except for sheet glass, which show a substantial increase. Sheet-glass production last year reached 2,856,500 cases (of 100 sq. ft.), an increase of 642,000 cases, or about 30 per cent, compared with the previous year. It is believed that Japan stood for the first time in 1933 at the head of the sheet-glass producing countries in the world. This is rather marvelous considering the fact that Japan is rather deficient in resources for glass manufacture in contrast to the United States which possesses cheap natural gas for heating and Belgium which is rich in raw materials for the glass industry.

"The production for the whole present year is expected to attain the high level of 3,500,000 cases, judging from the fact that the first four months' figures have already reached 1,110,000 cases, compared with 926,000 cases in the corresponding period of last year.[1]

"The present production capacity of sheet glass is in the neighborhood of 3,800,000 cases, which is divided into 3,000,000 cases for the Asahi Glass Company and 800,000 cases for the Nippon Sheet Glass Company. If the capacity of 500,000 cases for the Shoko Glass Company at Dairen, a daughter company of the Asahi Glass Company, were added to the figures above-mentioned, the total would be 4,300,000 cases.

"Until a year or two ago the range of thickness of sheet glass produced in Japan was rather limited, but has now greatly widened and, today, covers from 1.1 mm. to 10 mm.

"Contrary to the great development of the sheet glass industry, Japan falls far behind other glass producing countries in the manufacture of polished flat glass. The demand for polished plate glass, which is estimated to be still at a relatively low level of 24,000 to 28,000 cases a year at present, entirely depended upon imports until late in 1932, when the Asahi Glass Company marketed for the first time home-made polished flat glass. Quite recently, the Nippon Sheet Glass Company also has placed this article on the market. It may be worth mentioning that the polished flat glass produced in Japan is obtained from sheet glass made by Fourcault or Colburn machines, and not, as usual, from rough plate glass obtained by casting molten glass."

Czechoslovakia

This country has received scant notice in connection with the Belgian treaty news. But as she benefits to the same extent as Belgium (and without giving a single *quid pro quo*), it is more than probable she may become an important factor for future consideration.

The Czechoslovakian glass industry is desperately in need of business. When the Republic was instituted in 1918, there was production activity for all kinds of glass calculated for a home market of 50 million people and for sizeable world markets as well. With the domestic market reduced to 15 millions, the industry became more than ever dependent upon exports; but these have been shrinking steadily until 1934 reversed the downward curve.

Considering the glass industry as a whole, only slightly more than 120 of all the glass works were in operation throughout 1934. And while between 40 to 50 thousand workmen normally are employed, about half were idle at the close of the year.

This shrinkage is said to be due to the currency and tariff restrictions erected by foreign countries. As a result, a law was passed just one year ago this month (April) forbidding the reopening of a closed factory, the establishment of new plants, or any increase in existing capacities without a permit from the Minister of Commerce. A number of important consolidations took place.

Plate glass accounted for more than 19 per cent of the total glass exports from this country last year. Due to the low wage scale and the low cost of raw materials, Czechoslovakia is always a competitor to reckon with and the need for business is certain to make manufacturers quick to take advantage of any trade opportunity.

[1] Although complete production figures for 1934 have not yet reached the United States, the Bureau's optimistic estimate of 3,500,000 cases has so far proven remarkably close, and might have been realized had it not been for a slump in the month of August when output fell off 50,000 cases instead of showing an increase. Including the month of October, Japanese production of sheet glass amounted to 2,544,800 cases for 1934, which compares with 2,218,800 for the some 10 months the preceding year. However, November and December are big production months in Japan, and only a slight gain over 1933 was needed to attain 3,250,000 cases.

DINNER TO H. H. BLAU

On Saturday, March 9th, a group of more than 40 associates in the Macbeth-Evans Glass Company gave a dinner to Dr. H. H. Blau at the Nemacolin Country Club, Charleroi, following the awarding to him of the degree of Doctor of Philosophy by the University of Pittsburgh. The occasion came as a complete surprise to Dr. Blau, who was even more non-plussed when President George D. Macbeth, chairman and toastmaster, introduced the guest of honor, Dr. Herbert Insley, of the Bureau of Standards. Other invited guests were Professor H. S. Hower, Carnegie Institute of Technology, and Dr. R. R. McGregor, Mellon Institute of Industrial Research.

Chairman Macbeth opened the festivities by warning Mr. Blau that he was going to be taken for a ride and that he might just as well enjoy what was coming. He then sounded the key to which the evening was attuned by quoting "Lay on Macduff and damned be him that first cries 'Hold enough'?!" A more complete idea of the ensuing events may be had from the program which describes the dinner as "A Glass Gathering full of Seeds, Scum, Stones, Blisters and Gas."

MISS DENEEN TO REPRESENT THE GLASS INDUSTRY

The Special Libraries Association will hold its 27th annual convention in Boston June 11 to 14 with headquarters at Hotel Statler. This live and rapidly growing organization has now a membership of over 1600 trained librarians who manage the libraries of industrial concerns, research laboratories, banks, business offices, newspapers, museums, law, medical, scientific, and other societies, as well as the specialized departments in large public, college and university libraries—in fact, any library devoted to one special field. The Science-Technology Group, with a membership of over 200, is one of the most active and alert. The glass industry is represented here by Miss Catherine G. Deneen, librarian at the Corning Glass Works, Corning, N. Y.

IF YOU GO TO RUSSIA

Expansion of the glass manufacturing industry in the U.S.S.R. is leading Soviet Government to seek the services of American experts. Lack of familiarity with living costs in Russia and the many unexpected rules and regulations laid down by its government combine to create pitfalls which the American technologist can easily stumble into to his own detriment. Consequently THE GLASS INDUSTRY has asked some of its friends—engineers who have seen considerable service in that country—to erect a few sign posts from their own experience. These are given below. It is the first time to our knowledge that information of this kind has ever appeared in the American press.

Whether the engineer goes as an individual or as a member of a group he should see that the following points among others are covered in his contract.

(A) Adequate provision for first class transportation expenses to and from America to place employment. While in many parts of Europe, second class transportation is quite satisfactory, the traveler should insist that his transportation should be first class upon any boat, train, or other means of conveyance that takes him into Russia.

(B) The extent to which payments will be made in dollars in the United States and rubles in Russia. He should insist on receiving as large a portion of his remuneration as possible (50 per cent at least) in dollars paid him in the United States. A suggested rough and ready rule of figuring is to decide what salary you would expect to receive in the United States and have the Russian government deposit that amount monthly with your bank in the United States. Arrange with the bank to telegraph you when the deposit has been made. Next arrange in your contract to receive in addition twice that amount in Russian rubles payable to you in Russia. It must be remembered that foreign money can only be brought out of Russia to extent to which it was taken in, less the amount the authorities decide he should have spent while in Russia. After residing in Russia for a certain length of time, no foreign money can be brought out.

(C) Amount of money the engineer will be required to spend in Russia. Visitors to Russia are required to spend a certain minimum per day and the engineer should inform himself to what extent these regulations apply in his own case. Expense for such items as fuel, light, heat and rent should be stated definitely as not to exceed ... (state definitely) amount of rubles.

(D) Freedom from taxation of amounts paid in the United States and definite understanding as to amount of taxes on wages paid in Russia and understanding as to all other taxes.

(E) Provisions of living quarters including water, heating, light, cooking and sanitary arrangements, either free of charge or at a definite price.

(F) Supply fuel for heating and cooking and at what price.

(G) Supply of food and privilege of purchasing food, clothing and other supplies at commissaries established for foreign diplomats and engineers. Food books to be furnished.

(H) Privilege in regard to taking in with him and also importing later into Russia foodstuffs, clothing, toilet articles, etc., free of duty and a guarantee that they will arrive. (One man had to pay 800 rubles duty on a bottle of ink.)

(I) Outlining of duties and responsibilities of the engineer.

(J) The conditions under which employees are privileged to resign with safe conduct and expenses back to the United States, etc.

(K) Discontinuance at one job not to give Soviet the privilege of transference to another.

BAUSCH AND LOMB OPENS CANADIAN PLANT

In order to meet growing requirements of the Canadian market and also further to develop its export business in other countries of the British Empire, the Bausch & Lomb Optical Co., Rochester, N. Y., has formed a Canadian subsidiary and established an Empire headquarters and factory at Toronto.

GLASS MAKING IN BRITAIN 100 YEARS AGO

By H. W. LEE

NO HISTORY of glass making would be complete, or even comprehensible, without mention of the Excise tax imposed in England prior to 1845. These duties were payable: (1) An annual payment or license for each glasshouse; (2) payment per pound on all glass melted in pots and ready for use; (3) payment per pound on the excess in weight of manufactured glass over 50 per cent of the calculated weight of molten glass. The effect of these combined imposts was stated in evidence in 1842, to amount to two shillings nine pence per square foot on the finished glass.

Under the licensing system no sheet glass could be made in a bottle glasshouse. Certain materials were specified. For instance, the alkali permitted to be used in bottle glass making was soap boilers' waste. In addition to the crippling effect of Government rules, the constant supervision of Excise Officers must have been the source of considerable friction, delay and expense. Two Excisemen had to be quartered on the premises. The opening and closing of every annealing oven and the removal of every piece of glass was supervised. No crucible could be put in a furnace, or filled with glass, and no glass could be removed except in the presence of the Excise Officers. There is a glass factory in London which today still shows the bolts and locks attached to the ovens by the Excisemen, as well as the iron gauging rods by which the officers estimated the amount of glass in the pots. The sentry boxes in which they kept guard day and night have only recently been removed.

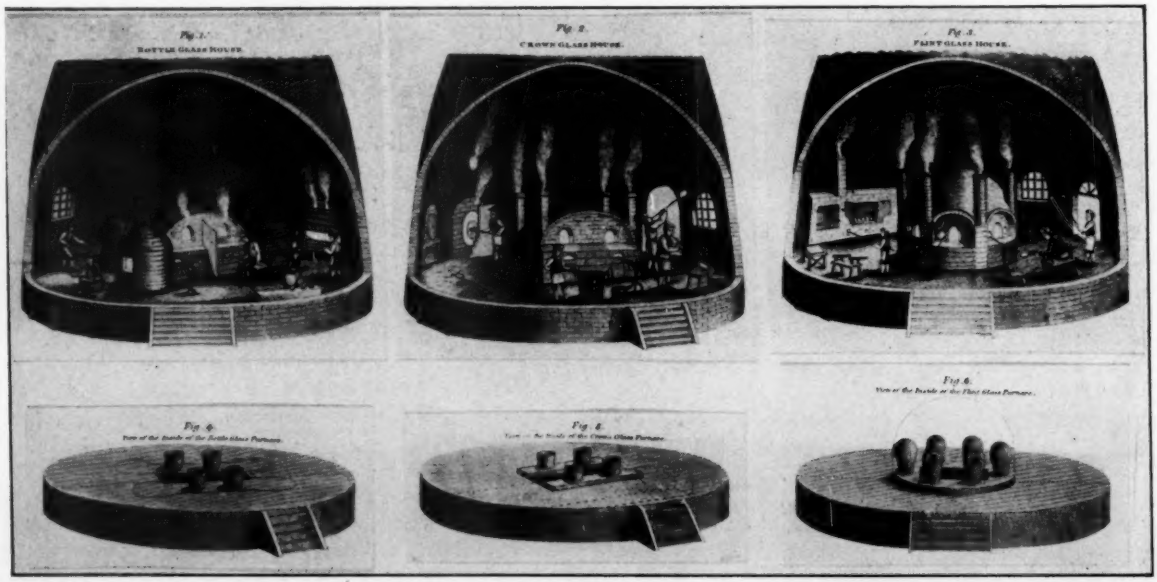
The experience of Cookson & Son, of South Shields, furnishes an interesting example of the results of this unending supervision. In 1831, they began the manufacture of Fresnel's dioptric apparatus for lighthouses, but after making 13, were compelled to abandon the enterprise because of the Excise regulations. These regulations forbade the use of crown glass refuse; specified that sheet glass must be limited to one-ninth of an inch thick and that plate glass must be between one-eighth and five-eighths of an inch thick.

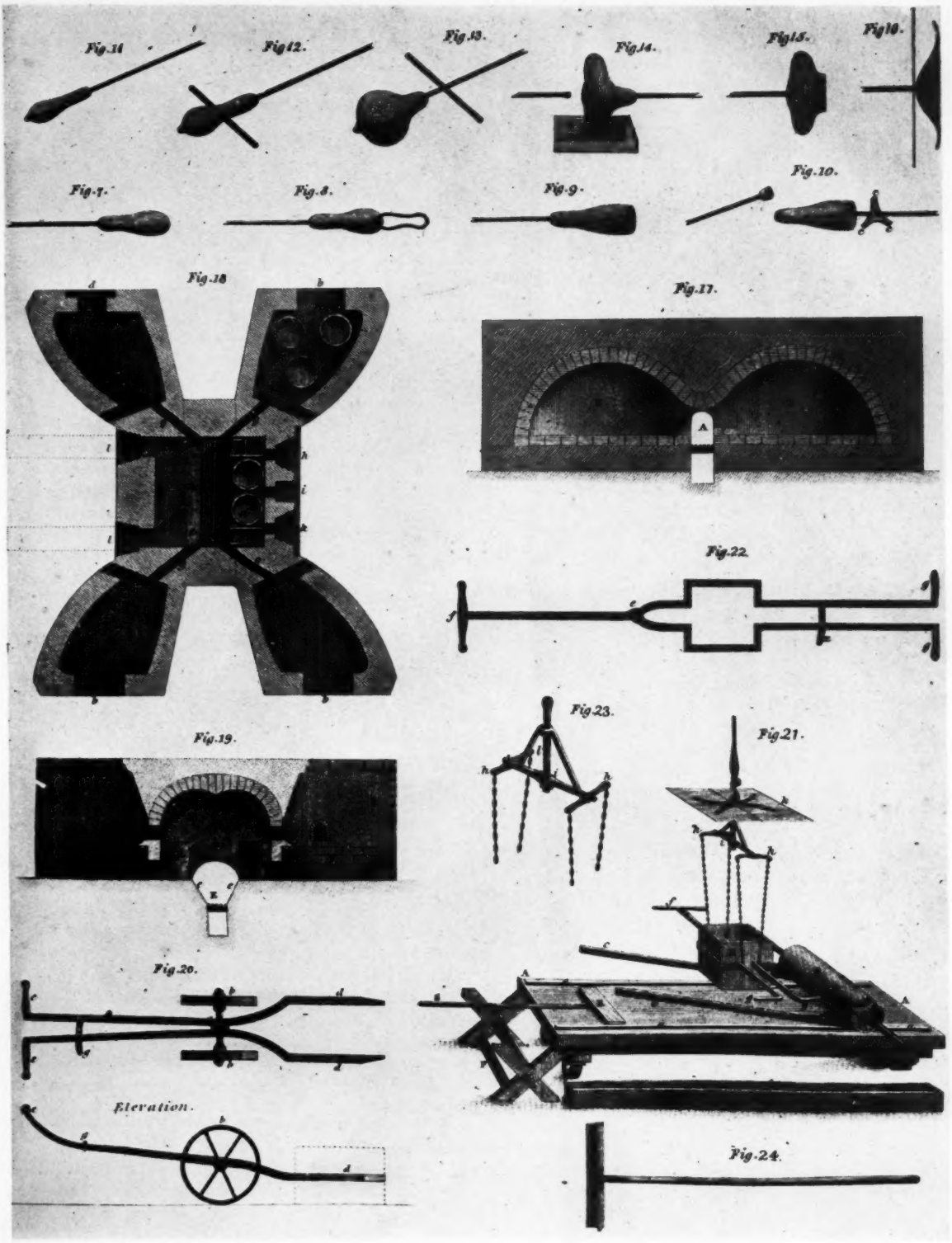
The result of all this regulation was that illicit glass furnaces came into existence. Small manufacturers, working in dingy basements, melted up broken glass. As a concession to the English glass industry a tax was levied on imported glass and a bounty was placed on all English glass exported. However, the bounty exceeded the import duty, with the result that enterprising British manufacturers found it profitable to send their glass abroad and then re-import it into England!

The illustrations in this article, from Brewster's Edinburgh Encyclopaedia, published in 1837, clearly show the methods of glass making during the last few years in which the British glass industry carried the burden of these special taxes. When the legislation was repealed in 1845 the industry immediately sprang into great activity and many changes were made.

The glass houses in use during the period of the Excise were huge cones from 60 to 100 feet high, and 50 to 80 feet in diameter at the base. They formed striking features of the glass towns in those days. One existed until a few years ago at Messrs. Pilkington's works at St. Helen's, Lancashire. The furnace was erected in the centre over a large air channel extending from one side of the cone to the other with an iron grating for the fire in the middle, above which the furnace was built. Doors for regulating the heat closed the ends of the channel. Melting took place entirely in pots, which were very much like the pots used today for making optical glass. The pot for making window glass was 40 inches in diameter at the top, 30 inches at the bottom, and 40 inches deep.

Wood was the principal fuel, although coal had been tried a hundred years earlier, and was used for main-





taining the furnace at a "working heat" for some hours. In 1829, the St. Gobain Co. melted in a coal furnace and fined in a wood furnace. Later, when the transference from the melting to the fining furnace pots was abandoned as wasteful, the whole process took place in a wood furnace. In fact the Company purchased a forest for fuel about this time. *Bottle Glass* (*Figs.* 1 *and* 4).

The furnace for making bottle glass was an arched oblong structure, built round the grating, on either side of which were the pots. There were four working holes one foot in diameter corresponding to the pots, and at each angle a circular "calcining" furnace (also

with a working hole) communicated with the main furnace. There were generally eight other furnaces, six for annealing the bottles and two for annealing the pots before putting them into use. The materials consisted of the commonest sea or river sand mixed with soap boilers' waste. The government at that time allowed no other material for bottle making.

The soap waste was calcined in two calcining furnaces for 24 to 30 hours to make "coarse ashes," which were then mixed with the sand. The mixture was put into the "fine" arch and calcined for 10 to 12 hours. The pots were filled out of the "fine" arch and melted for 12 to 18 hours after the final filling. The doors of the air channel were then closed, the pots skimmed and the furnace filled with coal to maintain a "working heat." Six people, gatherers, blowers and finishers were employed to make a bottle.

An inferior window glass was made with the same materials with the addition of kelp.

Crown Glass (*Figs.* 2 *and* 5)

In making crown glass, four to six pots containing 1,600-2,000 lbs. were arranged as in the bottle making house. In addition to the melting furnace there was a reverberating calcining furnace, a flashing furnace, a bottoming hole, and several annealing arches for glass and pots.

The materials, kelp and fine white sand, were first calcined for three hours to burn away the impurities, together with a good deal of the alkali. After melting and stirring for two hours, the material was spread out on a plate and divided into cakes. The "frit", as it was called, was supposed to improve with age, and was stored for about six months, after which it was melted with cullet.

The process of making the sheet is shown in Figs. 11-16. Fig. 14 shows the bottom of the globe being warmed up at the bottoming hole, which had a wall in front for the protection of the workman. The globe was then cracked off and transferred to another rod, O, and opened out at the furnace by spinning till a flat plate three feet six inches to four feet in diameter was obtained. The plate, supported on its edge by an iron frame, was then cracked off and annealed in the annealing oven. This wasteful process was customary in making window glass at that time.

Sheet Glass

In 1832, Chance's introduced into England the manufacture of sheet glass ("German Plate" as it was then called) from blown cylinders. The Continental process up to that time is shown in Figs. 7-10. Chance's brought over a manufacturer and several French and Belgian workers to start the process in England, and many improvements were made. The cylinders were blown larger and allowed to become cool before being split. This was done neatly with a diamond instead of by the crude method of hacking with iron shears. They reheated the open sheet and flattened it on a bed or "lagre" of smooth glass instead of on an iron plate covered with sand, and thus obtained a better finish. In a few years the superiority of Chance's sheet glass was universally acknowledged. In 1835, of the 30 English window glass manufacturers, 28 made Crown glass and only two made sheet glass.

Flint Glass (*Figs.* 3 *and* 6)

The materials used for flint glass were fine white sand, washed; red lead or, for best glass, litharge; and purified pearl ashes. Nitre, and sometimes arsenic, were added in small quantities and, if necessary, black manganese oxide to correct the color. Six covered pots are shown in Fig. 6. The pot openings were closed with clay after the pots were filled, but a small hole was left to allow the "sandover" to escape. This escape was assisted by a slight declivity in the surface of the molten metal, because the back of the pot was hotter than the front. Forty-eight hours were required for the melting.

Optical Glass

Although ordinary flint glass was supplied to the telescope maker for making achromatic object glasses, experiments were being made even before the discoveries of Guinand, to obtain a better glass, as the following description will show. The red lead, as pure as possible, was sifted through silk. The other ingredients nitre, white chalk and white sand, were also required to be as pure as possible. The sand was calcined, washed with sulphuric acid, and purified with hydrochloric acid. The ingredients (amounting to 12 oz.) were put into a platinum crucible and heated in a bottle glass furnace for 36 hours, poured into water, dried and pulverized. The powdered glass was washed and purified in the same manner as the sand, then remelted and the process repeated. After the third melting it was said to be free from all veins and impurities.

Cast Plate Glass (*Figs.* 17-26)

The method of casting plate glass was invented by Lucas de Nehou in 1691, and shortly after it was applied at the St. Gobain works in France. The process was introduced into England in 1773, at Ravenhead, Lancashire, where the original casting hall is still in existence. It is owned by Messrs. Pilkington; is 113 yards long by 50 yards wide, and looks like a cathedral.

Because of the secrecy surrounding the manufacturing process, as in the case of sheet glass making, it was necessary to import foreign workers to teach the English workmen. The same thing had happened when plate glass making was begun, and as the industry was under Government control (Excise regulations) the first company to undertake manufacture of cast plate had to be incorporated by an Act of Parliament, which provided stringent regulations against leakage of trade secrets! The factory was enclosed by a strong wall, within which were the workmen's dwellings. The penalty for breaking in with intent to steal or damage glass or tools was "Transportation" to a penal colony for seven years.

The process of casting was essentially the same as that used today. The best alkali was obtained from ashes of barilla (a bush grown in Spain) by lixiviation; otherwise purified pearl ashes were used. Borax was also added together with a small quantity of lime. The material was first calcined by spreading it on the floor of the calcining furnace (Fig. 17), during which process it was stirred and turned over. Fig. 18 shows the melting furnace. The three ovens (B B B) were for burning the pots and cisterns; D was for heating the "frit" before loading it into the pots. Two pots and two cisterns are shown in the furnace. When the material was almost

(*Concluded on page* 124)

EQUIPMENT AND SUPPLIES

CATALOGS RECEIVED

Refractory Insulating Brick. The Charles Taylor Sons Company, Cincinnati, O. Describing in detail tests made in a well-known fuel laboratory that demonstrate the advantages of Taylor Refractory Insulating Brick. The laboratory tests are supplemented by further tests made under practical operating conditions; for which complete engineering data are given.

Industrial Propane Gas. Bulletin 47 of the Phillips Petroleum Company. A description of the product (liquified gas for consumption in gaseous form); its method of utilization, transportation and storage; and its advantages and economies as a fuel. Copies of the bulletin may be secured by addressing the company, care of the Philgas Department, General Motors Building, Detroit.

Reducing Costs in Boiler Room and Plant Processes. Brown Instrument Co., Philadelphia, Pa. A folder illustrating various types of equipment manufactured by this company, and supplemental to the "Power Plant Instrument Data Book."

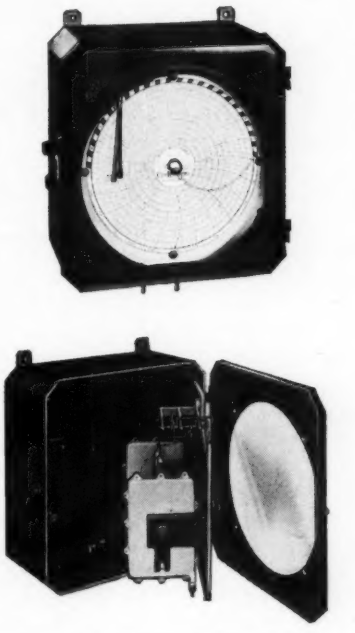
Bulletin No. 1425. Link-Belt Company, Indianapolis. A 32-page book, profusely illustrated, showing the industrial applications and advantages of this type of drive.

HAYS ANNOUNCES SUPERSENSITIVE RECORDERS

As the result of two years experimentation, the Hays Corporation, Michigan City, Indiana, has perfected two highly sensitive instruments for recording low ranges of draft and temperature. The development is one to which the glass industry has become specially responsive of late years. The instruments are known as the series OT sensitive, and the Series OH super-sensitive, and they will record draft, pressure or differential ranges between .1 inch and 100 inches water.

In both models, the diaphragms contain more than 30 inches of area, the pen arms are suspended on pivot bearings, hang vertically, and touch the face of the chart with a minimum of friction.

Because of its extreme sensitivity and the fact that a counter weight rather than a spring opposes the diaphragm movement, the OH recorder must be hung with the case level, for which a spirit level is built into the instrument. The standard charts cover ranges from 0 to .1 and 0 to .4 inches water. The standard model



is provided with only one pen arm, but space is provided in the case for a smaller diaphragm to actuate a second pen over a harmonizing OT range.

The OT recorder is furnished in either the single or two pen types. Three sizes of diaphragms are used to record over a range from 0 to .5 inch water to 0 to 100 inches. Charts reading in millimeters and special ranges to meet special requirements can be furnished to order. The OT case does not require accurate leveling.

The first complete factory for the exclusive manufacture of Diesel electric locomotives ever to be built in this country will be erected shortly in Chicago by the Austin Co., Cleveland, for the Electro-Motive Corporation, a subsidiary of General Motors.

LYNCH CORPORATION SENDS EXPERT TO HELP SOVIET

The Lynch Corporation, Anderson, Indiana, have loaned one of their glass machine experts to the Soviet Government. On March 13, Ray Thomas, an expert on machines, feeders and the fabrication of glass, left Anderson for New York City, where he took sail for Russia. It is expected he will be gone for six months.

NEW CONVERTIBLE MOTORS

An entirely new line of convertible squirrel cage and slip ring induction motors, offering all standard frequencies for service ranging from 110 to 220 volts, has just been announced by the Harnischfeger Corporation, Milwaukee, Wisconsin.

The outstanding feature of these new P&H motors is their ready convertibility from open type to fan cooled, splash proof or totally enclosed construction. This is accomplished through the design of the frame, end-heads and bearings to permit interchangeability in the four above-mentioned types of single or multi-speed squirrel cage and slip ring motors.

This development in standard AC motors is especially significant because of the adaptability of these units to various service requirements.

COMPACT PYROMETER

A pyrometer which requires no charts, lead wires, correction tables and be operated by unskilled hands recently has been brought out by the Pyrometer Instrument Company, New York City. It is only necessary to thrust the point of the instrument into a batch to directly read the temperature on the gage. This may be done in a matter of seconds after the material is drawn from the melting tank.

A small red push button near the scale operates a patented clamping device that either releases the indicating pointer or holds it as the operator may desire. Thermocouples may be attached in a very few seconds when necessary and will last for some time.

FOREIGN TECHNICAL PAPERS

SUMMARY TRANSLATION by SAMUEL R. SCHOLES

Futuristic Glass-Furnaces

GLASTECHNISCHE BERICHTE for December, 1934, publishes two papers which describe furnaces of radical design for melting and refining glass. A third article, by J. Lamort, is anticipated. Editorially, no claim is made that these designs are practically capable of superseding standard tanks, but the point is made that some developments seem to be called for, if melting procedure is to keep pace with the swift march of progress in mechanical glassworking.

I. *A Rotary Furnace.* Dr. Georg Zotos presents a rotary furnace. In his preliminary discussion of the problem of improving glass-furnaces, he names as requirements of the ideal furnace: good fuel-economy, long life, flexibility of operation, and the production of homogeneous glass. Present-day furnaces do not combine these ideals, chiefly because fuel-economy and flexibility of operation cannot be associated.

Siemens, it is remarked, made the only noteworthy contribution to progress in glass-melting technique, with his regenerative system. This produces the high temperature necessary for fuel-economy. But the next necessary step, revision of the form of the furnace itself, remains to be attempted.

The generation of very high temperatures (over 2000°C), by rapid combustion and high velocities of flame, is now perfectly feasible. But this involves a terrific loss of heat through furnace walls. These may not be insulated, because this promotes corrosion by the glass. Cooling is more often employed, to preserve the outer walls of intensely heated furnaces.

A new principle of furnace construction is formulated: by rotating a horizontal, cylindrical furnace, Dr. Zotos will cause the melt itself to form a lining as it clings to the walls of the cylinder, and thus expose a very large surface to the flame. The glass will be made essentially the furnace wall.

Before proceeding to a detailed description of the furnace, the writer discusses the fundamentals of glass-melting. Batch and cullet must be brought into a vis-

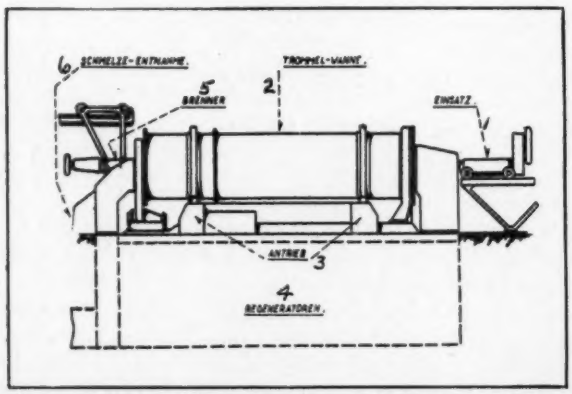


Fig. 1. Glass Melting Furnace, after Zotos. 1. Feed. 2. Drumtank. 3. Drive. 4. Regenerators. 5. Burner. 6. Outlet.

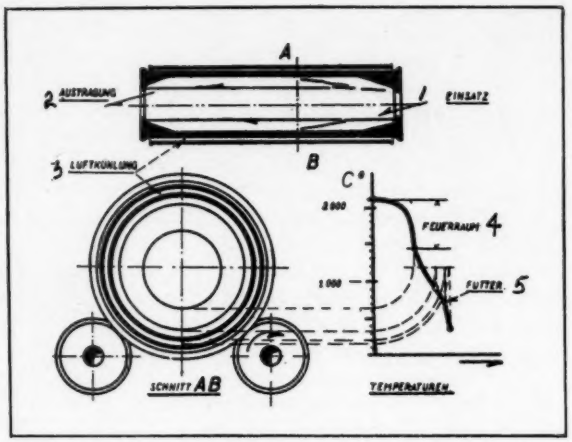


Fig. 2. Sectional View of Zotos' Furnace, showing temperature distribution. 1. Feed. 2. Outlet. 3. Air cooling. 4. Combustion space. 5. Lining.

cous, liquid condition, in which silicate reactions take place. Then the glass must be refined, before being brought to working temperature. A broad discussion of the attendant phenomena is omitted, but two factors are emphasized: (1) the spacing and timing of physical and thermal conditions for the whole process; (2) the need for a certain minimum time for reactions.

The first condition is met completely in pot-melting, where there is a constant volume in the reacting system. Therefore, pot-glass is of superior quality. Tanks meet only the second requirement, since they carry a more or less regular stream of molten material and allow time for transformations. Irregular and uncontrollable circulation in tanks, caused by convection induced by cold walls, upsets the gradation of time and volume conditions. This is overcome only by increasing the size of the melting unit, and thus flexibility is lost.

The author began developing the new type of furnace in Greece, in 1927, and some of his later work was reported in the *J. Soc. Glass Tec.*, Vol. 16, p. 284.

The cylindrical tank, rotating about a fictive axis, has its side-walls and crown virtually replaced by an active glass bath. The cause of destructive convection currents is thus completely removed and inactive surfaces, through which heat may be lost, are replaced by active surfaces taking up heat. This builds up the efficiency of the surface, its life, and capacity, per cubic meter of combustion space, since it offers the ideal cylindrical form of any desired length. The melting temperature is no longer limited by the refractoriness of the materials in the wall. It offers a new field of development for furnace construction.

The ordinary tank, as constructed at present, labors under several disadvantages. The cold side-walls cause cross currents and the insufficiently homogenized, or refined, mass sinks from the upper surface and generates a cordy condition. This disturbance prolongs the refin-

ing time since bubbles are carried under. The upper surface is more highly heated than the main body of the bath, causing exceptionally rapid corrosion at the surface. The crown is a great source of heat loss.

The new furnace may be imagined as formed from an

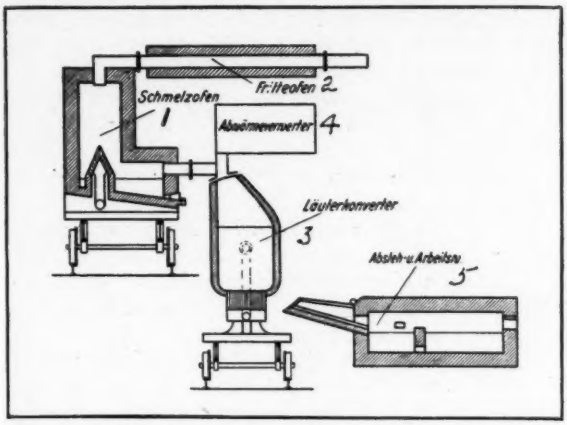


Fig. 3. Assembly for Intermittent Operation. 1. Melting Furnace. 2. Frit Furnace. 3. Refining Converter. 4. Heat Economizer. 5. Standing and working.

ordinary tank by rolling it about its longer axis until the two long sides meet and thereby disappear. They are replaced by the mantle of molten material. The evil effects of cross currents disappear because the side-walls disappear. The length can be whatever is necessary to get proper timing for the transformation phases: heating, gas evolution, melting, over-heating, refining, homogenizing and standing off.

Figure 1 is an exterior view. The various parts are named beneath the figure. The receiver for the finished glass for delivery to the machines is not shown. Fuel-economy, high capacity, ease of driving and uninterrupted production are attained. Increased production is secured, not by increasing size, but by reproducing typical units. Continuous operation for three or four years is possible. By hoisting away the drum by a crane and replacing with a new one, the unit can be placed into operation within eight hours from the shut-down.

Figure 2 presents a cross-section indicating the behavior of the thick layer of molten material clinging to the drum. The whole system is at relative rest in spite of the rotation. The highest temperature is in the core of the fire; the lowest, at the wall. Batch and cullet are fed from one end and, during their progress through the cylinder, the desired reactions take place. The high temperature applied means high heat-utilization. Losses are small. The insulation of the combustion space by the material in process makes for high efficiency. The refractory lining is spared, since the temperature of the outer wall is no higher than that of the bottom of an ordinary tank.

Economies of construction are indicated. The cost of building a new furnace, compared with an ordinary tank of equal capacity, is about 1:1.2. The floor space is 20 per cent less. When substituting the new tank for an old one, the regenerators can be used again. The substitution for the old style tank involves, therefore, small capital outlay.

An especial economy is offered by the possibility of using powdered coal for glass of the quality suitable for bottles. This depends upon the quantity of glass relative to the amount of ash produced being great enough so that the ash will not effect materially the composition or color of the production.

II. *A New Process of Glass Melting by Blowing Flame Gases Into the Glass.* Dr. Herman Passauer introduces a proposal for melting glass, utilizing an apparatus reminiscent of a Bessemer converter, in which the batch is melted and the bubbles removed by a blast of flame, blown upward through the melt.

Glass-melting has not changed in principle since ancient times. Heat is still applied to only a small surface and on account of the poor conductivity of the glass, efficiencies are seldom over 12 per cent.

Attempts to improve the procedure have been aimed at increasing the surface exposed, as by rotating furnaces, shaft-furnaces, and cascade furnaces. In none of these is the fire in immediate contact with the glass, but passes freely over its surface. The outstanding fact is, that melting itself is relatively simple and rapid, but refining is a time-consuming operation that wastes heat.

Figure 3 shows the assembly of the described process for intermittent operation. The batch in the form of briquets is fed into a frit furnace, fed by the flue gases, whence it is pushed by moving grates or the like into the melting furnace. More complete melting is accomplished here and the incomplete glass is drawn into the refining converter which is turned toward the melting oven to receive it. In the converter, the glass is blasted further; that is to say, flame gases are forced into the glass through orifices covering the entire bottom. The finished glass, homogenized, batch- and bubble-free, is emptied into the working tank by a further turning of the converter. It now stands off and is prepared for working. The flue gases from the refining converter can be conducted into the melting furnace, applied to the heating of the frit furnace, or used for the generation of power. Duplicate furnaces are mounted on cars for ready replacement. Power for moving the converter and for developing the necessary pressure for the blast is easily obtained from the flue gases.

Figure 4 represents the arrangement for continuous operation. The fritting and melting furnaces are the same as previously shown, but here, instead of one movable converter, there are three fixed, refining converters.

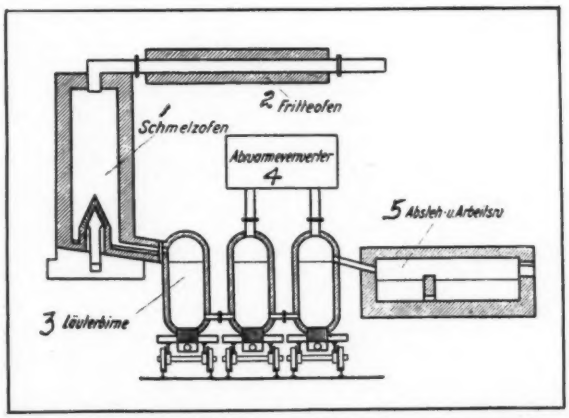


Fig. 4. Continuous Melting and Refining Process using Fire-Blast. 1. Melting Furnace. 2. Frit Furnace. 3. Refining Converter. 4. Heat Economizer. 5. Standing and working.

The half-finished glass runs through the three converters successively and passes out of the last one by gravity into the working furnace. The shaft furnace and the converters can be built either fixed or on movable cars. The preparation of the half-finished, sandy and bubbly glass can be made, besides in the process shown, by other installations of rotating furnace, cascade furnace, etc.

The rate of melting depends on temperature and surface exposed. The rate of refining (or plaining) depends upon: (1) temperature, and especially its rate of rise; (2) the boiling effect of large bubbles, their sweeping action upon seeds, and promotion of homogeneity. Accordingly, melting and refining can be furthered by: (1) hindering circulation between melting, plaining, and working portions, thus not accumulating large masses of glass; (2) applying very high melting and refining temperatures directly to the largest surfaces possible; (3) driving large, highly-heated gas-bubbles through the bath and thus rapidly making the glass sand- and bubble-free and homogeneous.

Previous attempts to clear the glass by blowing steam and oxygen through it have failed because the cold gases chilled the glass and defeated their own object.

The new method described in what follows is an improvement, in that it employs short-burning flame-gases, in combustion, which lessen the viscosity of the glass as they are blown into it from beneath, or from one side. In practice, this can be done: (1) by blowing a mixture of cold fuel-gas and air into the melt through small nozzles, whereby combustion occurs in the glass and back-firing is prevented by high velocity; (2) by compressing a mixture of gas and air just before forcing it into the batch or melt; (3) by burning gas with air in a tight combustion-chamber and forcing the flame into the glass; (4) by leading gas and air into the glass separately, through nozzles so opposed that combustion occurs in the glass.

Pre-heating of the fuel gas and air is accomplished with the help of the flue gas. Temperatures around 1500°C are attained without difficulty. Hydrogen and air without pre-heating will give flame temperatures of 1900-2000°C and a good producer gas will similarly reach 1600-1700°C.

The writer does not anticipate difficulty from the foaming or boiling over of the glass when it is blown with the burning gases. It is evident that the amount of gas introduced will not be proportionately greater than that generated in the ordinary block operations with wet wood, turnips, etc. in pots. The space above the glass in converters can be made as large as necessary so that foaming over is not to be feared.

The present disclosure is primarily a patent application, not yet developed beyond the small-scale laboratory stage, and presents thus far only an idea. No doubt, the practical development will bring with it numerous changes. It might be said at this time, however, that it promises a real improvement in glass melting beyond any of the known processes. In particular, the following advantages are foreseen.

1. Unfavorable convection currents and the accumulation of large masses of glass are avoided. The installation is small and cheap.

2. Melting down the batch, which requires 5-6 hours in a pot or 1-2 hours in a tank, takes place here in a fraction of the time.

3. The refining of the molten glass which requires 6-7 hours in pots and usually much longer in tanks, will be finished very rapidly in the new converter. Here the accelerators of refining: a rising temperature and continued strong blast, exert their combined effect.

4. Because of rapid melting and refining, the yield of the installation is very great. Hence, the heat economy is much higher than is possible at present, and the relative cost of installation, for a given tonnage, correspondingly lower.

5. The flue gases are available for power or preheating.

6. The use of expensive, high-grade, special refractories in the converters is quite economical since they will be necessary in such small quantities.

The writer expresses his appreciation of the request of the German Combustion Engineers for this disclosure, but he feels that it is perhaps too early for definite publication.

PROPERTIES OF GLASSES CONTAINING SODA, LIME, AND ALUMINA

If the 3-component glasses containing lime or alumina be regarded as soda-silica glasses in which a part of the silica is replaced by either lime or alumina, the effects of the replacements may be compared by using the properties of the soda-silica glass as a basis for comparison. In the following table certain data are given for an 80-per cent silica-20-per cent soda glass and also similar data for glasses in which 10 per cent of the silica has been replaced by alumina, lime, or soda.

Kind of Glass	Refractivity	Density	Coefficient of expansion to 400° C	Softening temperature	Coefficient of expansion to softening temperature
			μ/cm/°C	°C	μ/cm/°C
80% SiO_2... 20% Na_2O..	0.4890	2.380	0.107	527	0.116
70% SiO_2 .. 20% Na_2O.. 10% Al_2O_3..	.4982	2.428	.103	575	.124
70% SiO_2... 20% Na_2O.. 10% CaO...	.5220	2.522	.117	570	.132
70% SiO_2... 30% Na_2O..	.5018	2.463	.144	493	.160

It is evident that alumina produces the least change in refractivity and density, lime produces the greatest change, and soda is intermediate between lime and alumina in its effect.

Similarly, alumina produces the least change in coefficient of expansion, but soda produces the greatest change, while lime is intermediate. Lime and alumina produce about the same increase in softening temperature, while soda decreases the softening temperature.

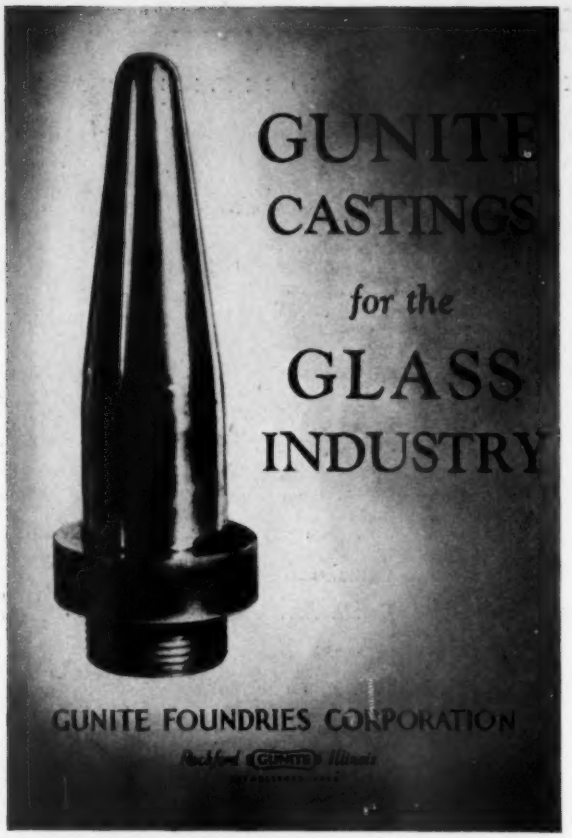
The values given in the table above were not obtained from actual glasses but by interpolation of data derived in the Bureau's studies of the properties of the soda-lime-silica glasses and soda-alumina-silica glasses.—*From Technical News Bulletin, Nat. Bur. Stds., January* 1935.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext. Per 100 lb.		...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	13.50	...
Tartaric	lb.	... { Po. or Gr. / Cry.	.25 / .25½
Alcohol, denatured, 50 gal. drum	gal.	...	.56½
Aluminum hydrate (Al (OH)3)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.10½
Antimony oxide (Sb_2O_3)	lb.	...	.11¾
Antimony sulphide (Sb_2S_3)	lb.	...	.11
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.05	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.02	.02¼-.02½
Powdered	In bags, lb.	.02¼	.02½-.02¾
Boric acid (H_3BO_3) granulated	In bags, lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—	lb.	...	.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	...	.215-.25
Cobalt oxide (Co_3O_4)			
In bbls.	lb	...	1.25
In 10 lb. tins	lb.	...	1.35
Copper oxide			
Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08	.085
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar—			
20 mesh	ton	10.00-12.25	
40 mesh	ton	10.50-12.75	
Granular	ton	10.75-13.00	
Semi-granular	ton	10.00-12.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	25.23	...
In bags	ton	26.83	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide ($Pb.O_4$) (red lead) (N. Y.)	lb.	.061	...
In 5 Ton lots	lb.	...	.065
Less than 5 Tons	lb.	...	.07

		Carlots	Less Carlots
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75-2.50	...
Litharge (PbO) (New York Prices)	lb.	.051	...
In 5 Ton lots	lb.	...	.055
Less than 5 Tons	lb.	...	.06
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.03
Manganese, Black Oxide			
In Paper bags	ton	45.00	50.00
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	...	.08⅝
Powdered	lb.	...	.09⅛
Potassium carbonate			
Calcined (K_2CO_3) 96-98%	lb.	.07⅛	.07⅝
Hydrated 80-85%	lb.	.06¼	.06¾
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.	...	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17-.18
Rare earth hydrate			
100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.3C
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	... { Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se)	lb.	...	2.00-2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	..
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.06½
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¾	.05¼
Sodium hydrate (NaOH) (caustic soda)			
Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97%			
Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.		1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) . in bbls.	lb.	...	.36½
Tin oxide (SnO_2) in bbls.	lb.	...	.51
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.60
Zinc oxide (ZnO)			
American process. Bags	lb.	.0575	.06
White Seal, 150 lb. bbls.	lb.	.10⅝	.10⅞
Green Seal bags	lb.	.09⅜	.09⅝
Red Seal, bags	lb.	.08⅜	.08⅝
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04 .0"



Hydrated
CARBONATE OF POTASH
83/85%
Manufactured now at Niagara Falls, N. Y.
A *New Domestic* product now made in *Crystals*, of uniform quality, especially for the Glass Industry.
Delivered in 400 lb. Barrels.
Generous samples sent on request.
JOSEPH TURNER & COMPANY
500 Fifth Ave., New York, N. Y.
Suppliers of Chemicals for over 70 years
MADE IN U.S.A.

GLASS MAKING IN ENGLAND

(*Continued from page* 118)

melted the pot was removed to I, and the material was loaded into the melting pots and fused for 36 to 48 hours. It was then transferred to the cisterns by means of ladles, where it remained for five or six hours before it was withdrawn through the opening L, and carried to the casting table, which was made of wood covered with copper. Annealing took 14 days. The plates were ground by rubbing two together, using sand as the abrasive. This grinding process took 36 hours. Polishing took 72 hours and was done by hand, although the steam engine had been introduced for that purpose as early as 1789. Small cloth polishers were used, pressure being obtained by means of a rod between the runner and the ceiling.

In 1833, the ordinary dimensions of the cast plates were five feet by eight. About 10 years later a plate 90 inches by 150 inches was made for the Reform Club, London, and for many years this remained the largest plate of glass in the world.

Dr. Alexander Silverman, Head of the Department of Chemistry, University of Pittsburgh, will deliver the annual Alpha Chi Sigma lecture at the University of Virginia, Charlottesville, Virginia, on the evening of April 11. The subject will be "The Glass Age."

BOOTS TO BUILD ANOTHER ALL-GLASS FACTORY BUILDING

Contract for a factory of a novel and advanced type, adjoining the all-glass factory which was opened at Beeston, Nottingham, England, in 1933, has just been placed by Boots Pure Drug Co., Britain's biggest drug chain. The existing factory is for wet products (creams, pastes, lotions, etc.). The new one will package dry products.

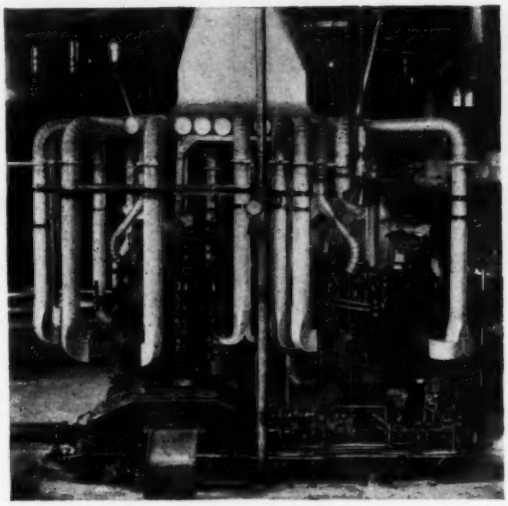
The entire structure, built of concrete and steel, with glass walls and roof, will, when completed, measure 600 feet by 400 feet. More than 1,000 workers will be employed on the construction, and the cost is estimated at £550,000 ($2,750,000). Like its neighbor, the new factory has been designed to secure the maximum efficiency combined with the maximum comfort of the workers, and to this end glass has replaced other materials wherever practicable. Spaciousness, airiness, and light will be conspicuous characteristics.

The first unit is scheduled to be finished by March, 1936, and it is expected that the installation of machinery will be completed by the beginning of the summer.

LONDON SECTION MEETS

The London Section of the Society of Glass Technology held a meeting on March 6 at which the topic for discussion was "Stoppers, Caps and Closures." Mr. T. C. Crawhall, Honorary Secretary of the section opened the meeting with a few introductory remarks on early forms of bottle closures. He was followed by Mr. T. Sutcliffe, who dealt with Sutax caps; W. T. Skelton, speaking on bakelite caps, and W. Gamble, on aluminum caps. Time did not permit reading of a communication on ground glass stoppers by Messrs. John Dowell & Sons, Ltd.

COOLING COSTS REDUCED!



Kirk & Blum improved cooling system on the new No. 10 Lynch Bottle Machine

Advanced engineering principles, careful designing, and installation by skilled erectors—these are the factors in K & B Cooling Systems that reduce power costs and increase production.

Records from installations in many of the larger glass manufacturing plants throughout the country show that because of the savings thus effected, K & B Cooling Systems soon pay for themselves.

Without obligation, our engineers will analyze your cooling problem and recommend where and how savings, if any, may be made. Write

THE KIRK & BLUM MFG. CO.,
2804 Spring Grove Ave.
Cincinnati, Ohio

DETROIT FACTORY: 4718 Burlingame
CHICAGO OFFICE: 3843 N. Central Park Ave.
Pittsburgh Representatives:
The Bushnell Machy. Co., 1501 Grant Bldg.
Louisville Representatives:
Liberty Blow Pipe Co., Inc., 325 Roland St.

KIRK & BLUM
Blower Systems

BORAX
AND
BORIC ACID

Twenty-Mule-Team Brand

Guaranteed 99½% to 100% Pure

Makes Glass More Durable and Resistant

Free Booklet on Request
"BORIC OXIDE AS A CONSTITUENT OF GLASS"

Pacific Coast Borax Company
Department G
51 Madison Avenue, NEW YORK, N. Y.

20 MULE TEAM

EMILITE
Mould and Plunger Iron

LONGER LIFE—BETTER WARE

Analysis to Suit Your Individual Problem

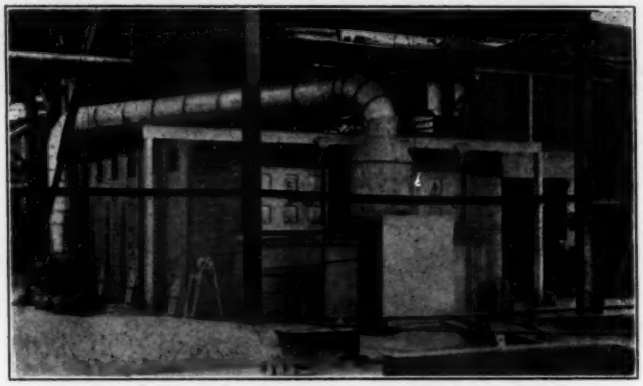
All Inquiries Receive Prompt Attention

THE MILLER FOUNDRY CO.
730 SHELDON AVE. COLUMBUS, OHIO

IMPROVED
REGENERATIVE TANK FURNACES

Are Now Built

On your Factory Floor
To Suit Your Factory Conditions
To Increase Quality Production
To Replace Present Obsolete Units
To Give Long Service
To Give Best Fuel Economy
To a Definite Performance Guarantee
To Dixon Standards at Moderate Cost



One Important Feature—Accessible Regenerators

You may not increase your melting area but you must increase your production tonnage. We can do it.

Demand Particulars

H. L. Dixon Company

"Everything for the Glasshouse"

Office and Works:
Rosslyn Road, Carnegie, Pa.

Mail Address:
P. O. Box 251, Carnegie, Pa.

Let us tell you about the

New Domestic

ISCO
CARBONATE OF POTASH

Calcined 96/98% Hydrated 83/85%

Special Glassmakers Grades.
Now made at Niagara Falls.

ISCO CHEMICALS

INNIS, SPEIDEN & CO.

117 Liberty St. New York, N. Y.

Chicago Cleveland Gloversville Boston Philadelphia

DESIGNS
MODELS
MOULDS
MOULD CASTINGS
Quality and Quick Service
....250 EMPLOYEES
OVERMYER
MOULD COMPANY
WINCHESTER
IND.

THE OTTAWA SILICA COMPANY

OTTAWA, ILLINOIS

ETERNAL AS THE SANDS OF TIME

The PRINCE of GLASS SANDS

The Famous OTTAWA WHITE SAND

THREE PLANTS TO SERVE YOU

OPERATING YEAR AROUND

EVEN NEW

CRYSTAL 99⅔% PURE SILICA

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING ENGINEERS

FOR THE GLASS INDUSTRY

LANCASTER, OHIO U. S. A.

BOTTLES

WT

FLINT - GREEN - AMBER
EMERALD GREEN

Full Automatic Machine Process

Whitall Tatum Company

Manufacturers Since 1836

Philadelphia New York Buenos Aires, A. R.

FACTORIES: MILLVILLE, N. J.

GLASS SPECIALTIES

Transparent Colored Blown Sheet Glass
Solid Pot Opal Blown Sheet Glass
Flashed Opal Blown Sheet Glass
Colonial Antique Colored Glass
Heat-Ray Resisting (Cool Glass)
"TWIN-RAY"—
the scientific
illuminating
glass.

HOUZEX

L. J.
HOUZE
CONVEX GLASS CO.
Point Marion, Penna.
New York Office: 110 West 40th St.
Chicago Office: 1597 Merchandise Mart
"IF ITS MADE OF GLASS, ASK US FIRST"

BAILEY & SHARP CO.
INCORPORATED

CONSULTING ENGINEERS

GLASS TECHNOLOGISTS

CABLE ADDRESS
"SHARPGLASS"

HAMBURG, N. Y.
U. S. A.

Make them "Standard Equipment" in your factory—

SUPERFLUX BLOCKS

A LACLEDE-CHRISTY PRODUCT

SAINT LOUIS, MO.

Patents Pending

The Controlled Luminous flame method of firing offers the following advantages:

1. **Fuel Economy**
2. **Complete Flame Coverage**
3. **Increase in Furnace Tonnage**
4. **More Homogenous Glass**
5. **Adaptability to continuous tanks and POT FURNACES.**

Our organization is equipped to render to the glass industry a complete service in plant design, appraisals and plant equipment.

THE TOLEDO ENGINEERING COMPANY, INC.

958 Wall Street Toledo, Ohio

MIN-OX
RESISTS SCALE

Regarding Moulds . . . . . .

MIN-OX alloys resist scale so well that cleaning and other operating expenses are greatly reduced.

MIN-OX Castings:—a series of alloys to meet varying glass production requirements.

THE BINNEY CASTINGS COMPANY

Toledo, Ohio

Originators Of Alloys For Glass Moulds.

for all types of glass decoration

GLASS COLORS ENAMELS ICES

FOR 65 YEARS

Specialists in Colors, Metallic Oxides and Chemicals for the GLASS INDUSTRY

METALLIC OXIDES AND CHEMICALS

Alumina
Antimony
Arsenic
Barium Carbonate
Bone Ash
Boracic Acid
Borax
Cadmium Carbonate
Cadmium Oxide
Cadmium Sulphide
Cerium Hydrate
Chrome Oxide Green
Cobalt Oxide Black
Copper Carbonate
Copper Oxides
Glass Decolorizers
Iron Chromate
Iron Oxides
Iron Sulphide
Lead Chromates
Lepidolite
Manganese Carbonate
Manganese Dioxide
Magnesium Carbonate
Neodymium Oxalate
Nickel Carbonate
Nickel Oxides
Nickel Sulphate
Polishing Rouges
Potassium Bichromate
Potassium Carbonate
Potassium Chromate
Powder Blue
Putty Powders
Rutile Powdered
Selenium
Sodium Bichromate
Sodium Selenite
Sodium Silico Fluoride
Sodium Uranate
Titanuim Oxide
Uranium Oxide
Whiting
Zinc Oxides
Zirconium Oxide

GOLD . . . SILVER . . . PLATINUM LUSTRE PREPARATIONS
Printing Tissues—Etching Supplies—Oils—Mediums—Banding Wheels—Brushes—Pallette Knives—Perfection Portable Decorating Kilns—Silk Bolting Cloth—Spraying Equipment—Grinding Mills.

ESTABLISHED 1869

B. F. DRAKENFELD & CO. INC.

45-47 PARK PLACE, NEW YORK, N. Y.

BRANCHES: East Liverpool, Ohio . . Chicago, Ill. . . WORKS: Washington, Pa. PACIFIC COAST AGENTS: Braun Corp., Ltd., Los Angeles . . Braun-Knecht-Heimann Co., Ltd., San Francisco.